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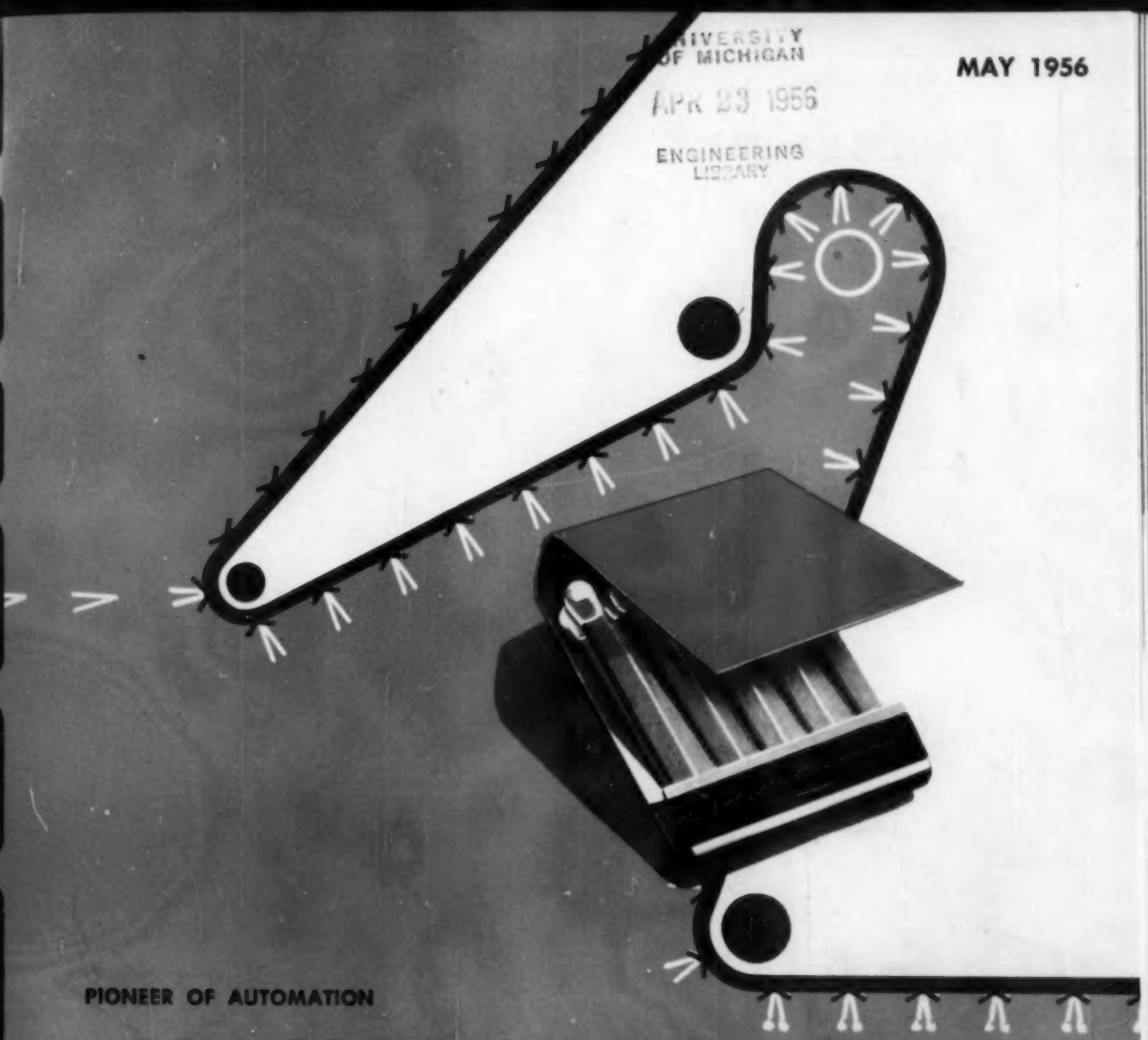

PIONEER OF AUTOMATION

Matchbook Manufacturing

The Magazine of Automatic Operations

- **Automated Electronics Manufacture**
- **Tape Programmed Testing**
- **Automatic Plating**
- **Linking Devices**

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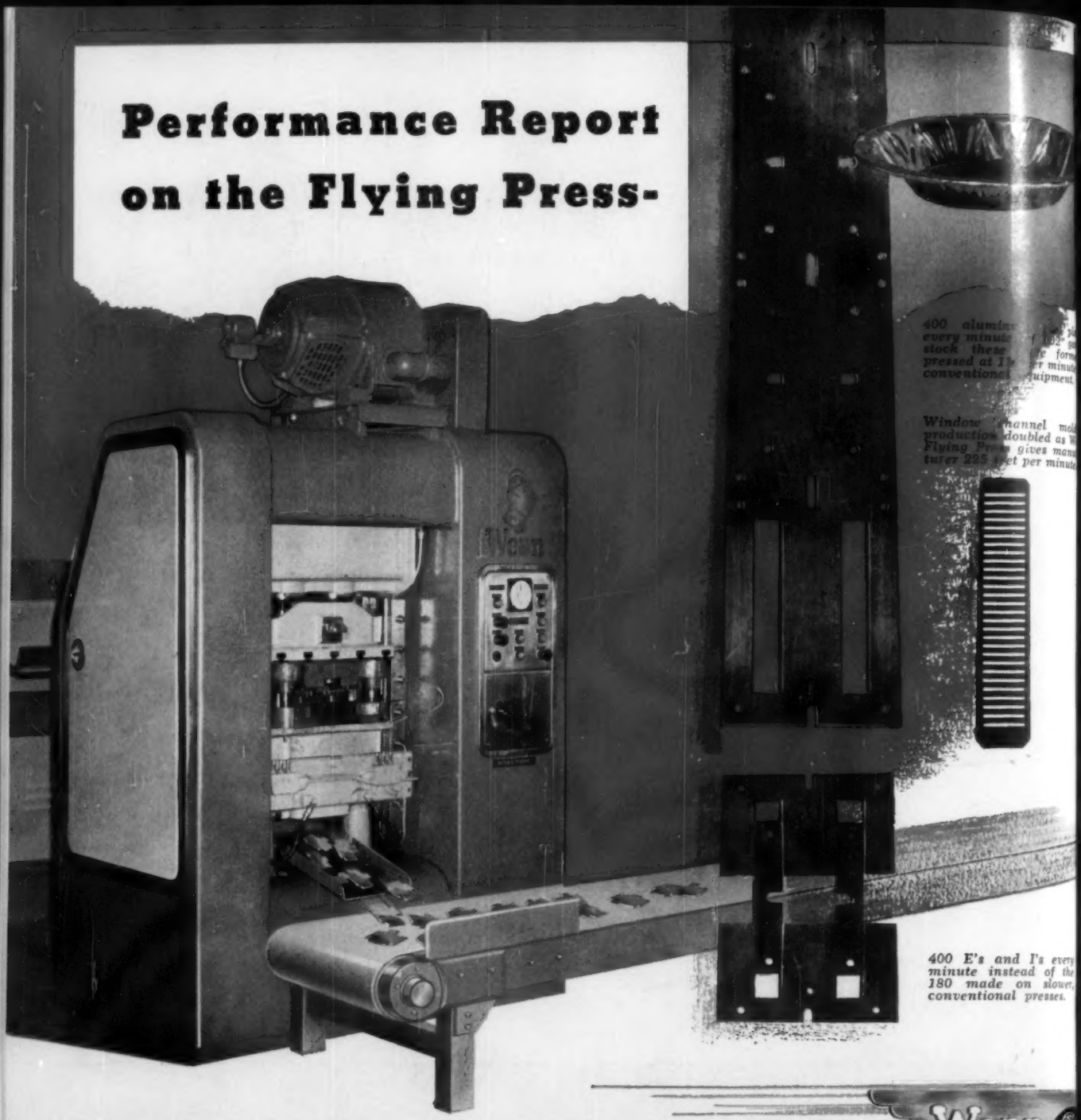
A PENTON PUBLICATION

Performance Report on the Flying Press-



400 aluminu... every minute ... stock these ... pressed at 1... conventional ...

Window ... production doubled as ... Flying Press gives manu... turer 225 ... per minute.

400 E's and I's every ... minute instead of the ... 180 made on slower, ... conventional presses.

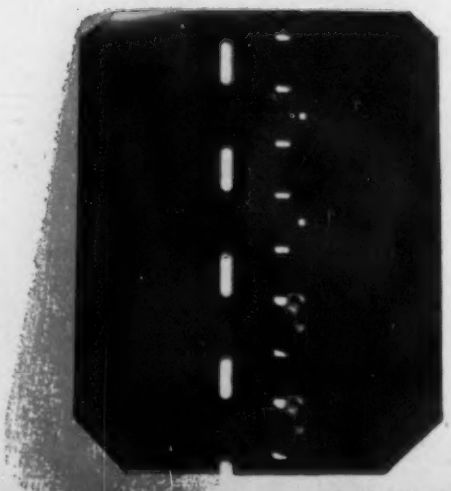
Revolutionary Wean Press continues to amaze the industry

Since it was first introduced to industry, the Wean Flying Press has commanded the interest of imaginative production people.

On paper, it looked good. Tests on the hand made prototype were even more convincing. But, could a production model achieve such levels under actual operating conditions?

For the answer—note the typical production figures set down here. In every case, the Wean Flying Press, using standard die sets, has established a performance record.

Why not acquaint yourself with this amazing press now? Contact the Wean Sales-Engineer in your area or write direct.



Shallow draw ... punch work on ... gauge stock boos... to 400 pieces ... minute by We... Flying Press.

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MAY, 1956
Vol. 3—No. 5

AUTOMATION®

THE MAGAZINE OF AUTOMATIC OPERATIONS

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automation outlook

REASONS FOR AUTOMATION

". . . before entering into a detailed discussion of automation in the Bell System, I should like to stress several basic thoughts. The first has to do with the reasons for automation in our companies. We have introduced dial equipment and many other scientific and technological improvements throughout the years for three basic reasons: To improve the quality and usefulness of telephone service, to satisfy the demand for service, and to keep the cost of our product at a reasonable level. The result has been a marked expansion of telephone usage over the years. Telephones and telephone calls have increased many times more rapidly than population, and even more rapidly than Gross National Product. . ." — *Clifton W. Phalen, president, Michigan Bell Telephone Co.*

INVOLVED IN AUTOMATION

". . . I propose that our industry work openly to promote automation, to answer those who misrepresent it, and to explain its benefits patiently and ceaselessly to those who stand to gain the most from it—the American people. No other American enterprise is so deeply and at the same time so variously involved in automation as ours. Since the emphasis of automation is on electrical control we will have an increasingly important part to play . . ."—*Gwilym A. Price, president and chairman of the board, Westinghouse Electric Corp.*

EFFICIENT BANKING SERVICE

". . . by pioneering in the field of automation, First National City is providing many of tomorrow's services today. Our adoption of the Burroughs E-101 is but one step in our program of developing and utilizing equipment of the most advanced design. By introducing this and other machines to bank operations we are taking a long step forward in offering to our customers the speediest and most efficient banking service . . ."—*George A. Guerdan, vice president and cashier, First National City Bank of New York.*

HOW MACHINE TOOLS FIT

". . . many of our shareholders have written asking how our line of machine tools fits into the much publicized, so-called automation field. Our answer is that the very essence of our engineering for the past sixty years has been devoted to designing and building automatic metalworking machines commonly known as automatic screw machines. Through intensive elaboration, these machines have been brought to such a high degree of efficiency that today our different models are being included in and form an important part of many plans presently being developed for more completely automating lines of mass production . . ." *F. H. Chapin, president and chairman of the board, The National Acme Co.*

NO TURNING BACK

". . . one thing we can all be sure of: There is no turning back. Automation is here to stay and the businessman who ignores that fact is going to find himself trailing the competition—just as the nation that ignores it is going to find itself in extreme jeopardy, both economic and military. Social problems created by automation are going to be solved not by trying to hold back the tide but by trying to control it and by building safeguards to withstand it . . ." *Joseph W. Barker, president, American Society of Mechanical Engineers.*

AUTOMATION

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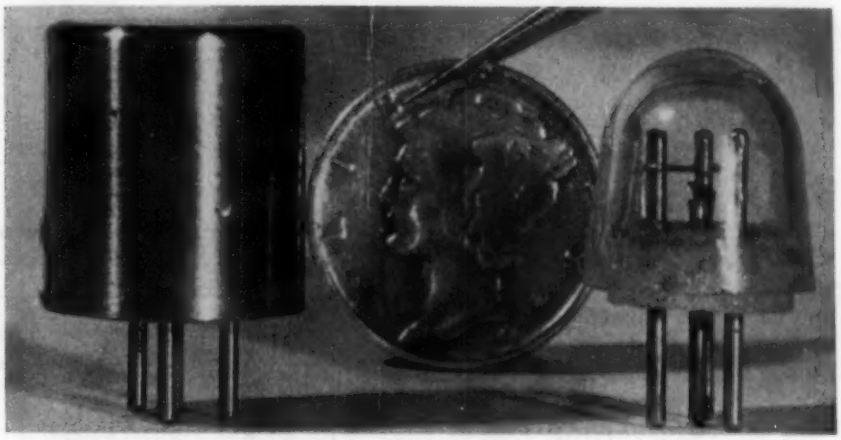
AUTOMATION news

Today's events and developments in the field of automation

New Transistor Development Breaks Frequency Barrier

RECENT developments in manufacturing techniques have increased the potential uses of transistors. With these advances, the probability of achieving completely transistorized circuits is closer to actuality. The Bell Telephone Laboratories has described a new fabricating technique which has resulted in an entirely new kind of transistor. Key to the new technique is the development of manufacturing controls over microscopic chemical layers. Involved is an adaptation of the chemical process of "diffusion" used in treating silicon for the Bell solar battery. It is a process by which minute amounts of impurities are introduced in controlled amounts into a material.

As is well known, transistors have been used for several years in place of vacuum tubes as low-frequency amplifiers. A major problem on which researchers have been working involves narrowing the base or center layer of the three - layer chemical sandwich which forms a transistor. The narrower the base layer can be made, the higher the frequency at which the device operates. With the new manufacturing technique, the resulting transistors have been developed which reach a cut-off between 500 and 600 megacycles, i.e., the frequency point up to which there is a straight, full amplification of a signal, and after which the signal is amplified with steadily diminishing strength. This frequency cut-off value which has been obtained compares to the 1 to 10 megacycle range currently available in transistors. Even though the effective operation of many electronic devices is in a much lower megacycle range than the new device makes available, the higher frequency cut-off will provide a greater number of communication channels or more amplification than previously possible. Development is under way preliminary to manufacture of the new type transistor.

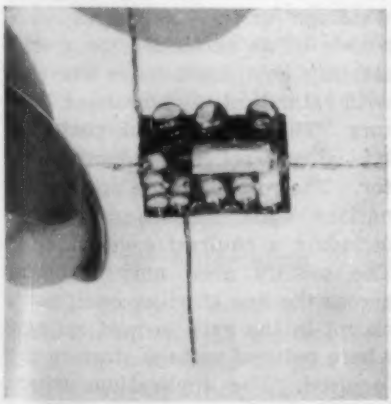


LABORATORY models of new silicon and germanium transistors recently developed by Bell Telephone Laboratories are shown in comparison with U.S. dime. Silicon transistor, with brass cap, is at left. Germanium transistor, glass capped, is at right. Chemical process of diffusion in which minute amounts of impurities are introduced in controlled amounts into the transistor is basis of new manufacturing technique which has resulted in a high frequency transistor. The device's characteristics pave the way for additional use of transistor in replacement of vacuum tubes.

A recent announcement by Texas Instruments Inc. also reports a new grown-diffused technique of manufacture which has resulted in a high frequency transistor. The units are available for commercial sales.

The manufacturing method as described is based on the principle of solid state diffusion wherein an ultra thin base layer is produced by the migration of added impurity atoms while the semiconductor crystal is being grown.

New silicon transistors now in production have gains of 15 db at 12.5 megacycles and 14 db at 30 megacycles with useful power levels up to 150C. The silicon forms are especially suited for use in



TINY demonstration amplifier has been constructed by the Philco Corp. to illustrate the capabilities of a new subminiature transistor. The demonstration amplifier has a 70 db gain, or a power gain of 10 million.

guided missiles, supersonic aircraft, computers and other applications where high temperatures are encountered.

The Philco Corp. has developed an extremely small transistor (20 can be placed on a dime) for utilization in electronic systems where miniaturization is important. Possible uses are in guided missiles, computers, hearing aids, etc. To illustrate the capabilities of the subminiature transistor, a demonstration amplifier has been assembled which has a 70 db gain or power gain of 10 million. One of the transistors will operate on as little as one ten-thousandth of a watt.

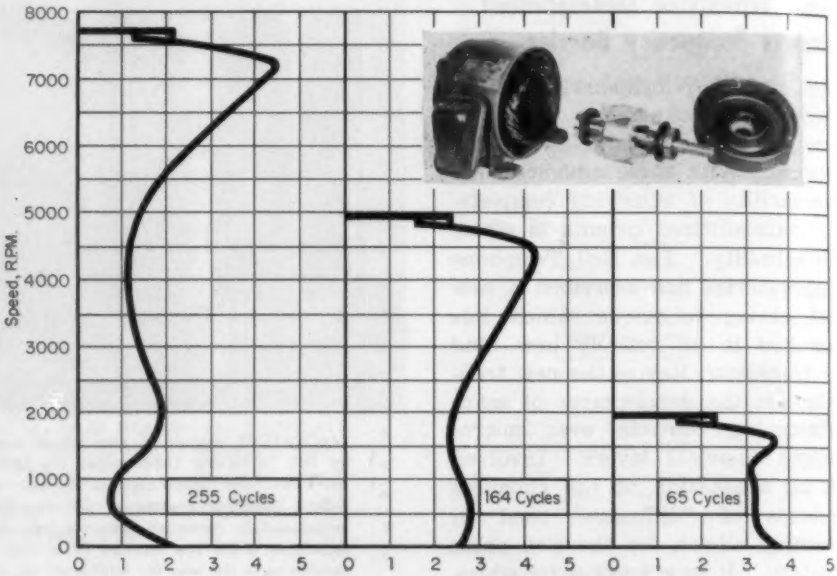
With continued improvements in both technological and manufacturing know-how, there appears to be no reason why the transistor market should not more than double in 1956, as has been frequently estimated. To date, hearing aids and radio receivers have been the biggest commercial users. Recently, one manufacturer has placed on the market a hearing aid which is completely contained in a unit which is placed directly in the ear. In that transistors cut size, weight, power consumption and maintenance cost of electronic equipment, there is a real incentive for manufacturers to adopt the units wherever practical.

Improved Performance With Synchronous Induction Motor

NEW synchronous induction motor for general industrial use has been developed at the Norwood Works of Allis-Chalmers Mfg. Co. Basically, the machine combines the constant speed characteristics of a synchronous motor with the low first cost, rugged mechanical construction, and simplicity of maintenance of the induction motor. The motor is available in ratings from ¼ to 40 hp. Its name, the Synduction motor, reflects its hybrid characteristics.

The Synduction motor accelerates as a squirrel cage induction motor. After reaching synchronous speed, it operates without slip from no load to pull-out. Beyond pull-out, the motor once again operates as a squirrel cage induction motor, slip is present, and speed decreases as load increases. Speed of the motor is directly proportional to the frequency, and, up to pull-out, is independent of load and of voltage. The units have been designed to operate over a rather wide frequency, and therefore, wide speed range. Operations at frequencies of 300 cycles, and at speeds in excess of 10,000 rpm, are possible with certain designs of these motors. Others have been developed to operate at low frequency in the ten cycle per second range, and consequently, at low speed.

If several Synduction motors operate from the same electrical source, then the ratio of the speed of any motor to the speed of any other of these motors cannot change. If the supply frequency is varied, then the speed of each motor changes by exactly the same ratio that the frequency changes.



SPEED-TORQUE curves for one model of Allis Chalmers' new Synduction motor at widely different frequencies are shown. The load inertia is 2.2 times that of the motor rotor. The pull-out torque averages about 175 to 200 per cent of rated torque. With certain designs of these motors, operation at frequencies of 300 cycles and at speeds in excess of 10,000 rpm is possible. The new motor features the same simplicity of construction that makes the squirrel cage motor relatively trouble-free and easy to maintain.

Effective use of the motors can be made in applications: Where the motor must operate at a constant, unvarying speed; where several motors must operate at a fixed ratio of speed of one to the other; and where the speed of a motor, or series of motors, must be adjustable over a speed range, with minimum variation at any speed setting.

As can be seen from the illustration, the mechanical parts, such as supporting frames, bearing brackets, bearings, etc., are similar to parts already developed for the squirrel cage lines produced by Allis-Chalmers. The motor requires no brushes, slip rings or windings on the rotor, separate source of dc excitation, or special starting equipment as is the case with standard synchronous motors. The stator is like that of a typical squirrel cage induction motor. The rotor is made up of laminations with die-cast conductors including a squirrel cage winding. The motors need only standard across the line starting equipment, except in the very largest ratings, where reduced voltage starters are required. For applications where operation of several motors must be synchronized over a range of speed, an electromechanical drive to supply variable frequency for the motor has been developed.

AEC Awards Contract For Ultrasonic Cleaning System

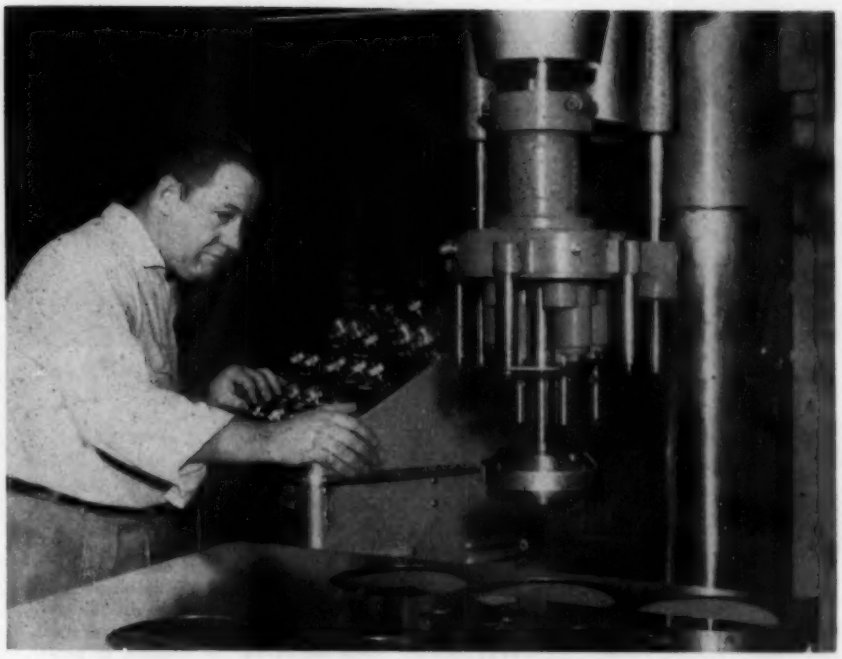
CONTRACT for the construction and installation of a large ultrasonic cleaning and degreasing system for an Atomic Energy Commission facility has been awarded to Acoustica Associates Inc., Glenwood Landing, N. Y. High-frequency generators totaling 20 kw will supply power for energizing hundreds of above audible sound generating transducers needed to irradiate materials being processed en masse. The scrubbing action of an ultrasonically agitated solution flushes impurities from the entire surface of the material being treated. Parts of critical importance to the A.E.C. will be microscopically cleaned in a fraction of the time required by conventional methods.

It is expected that the introduction of ultrasonic techniques in industry will be accelerated as a result of A.E.C. recognition. This could catapult the infant ultrasonic industry into a major position in the American economic scene. Gross sales are approaching the $200 million a year mark.

Only a few years ago, ultrasonics was considered a laboratory curiosity. Within the last year, reports **Robert L. Rod,** Acoustica's president, the development of low-cost, high-frequency generators of sufficient power to satisfy the heavy production requirements of industry and new techniques of transducer manufacture has enabled the ultrasonic industry to make great headway in such areas as automotive, aeronautical, electronic, electrical, precision parts and metal products manufacturing, as well as chemical, food, plastics, paper and textile processing.

Union School Prepares Members for Automation

UNION prepares members for automation by offering training program for new kinds of jobs that will be created. Local 1 of International Brotherhood of Electrical Workers in St. Louis, convinced that "the number of production jobs lost due to automation will be more than made up by increase in production of electrical equipment required," has opened what it calls a "post-graduate school" which offers training in new techniques in electrical field. Four hundred of its members signed up for three-year course and are now attending 38 different classes four nights weekly.



MACHINE control engineers of Minneapolis-Honeywell Regulator Co. have designed a control system for a special machine built by the Farwell Metal Fabricating Co. used to drill holes for mounting instruments and dials on master panel boards. Control system consists of dials with which the operator sets the desired X and Y co-ordinates of the center of holes to be drilled. A traveling drill head and movable table permit positioning of the cutting tool over the workpiece. The drill head, equipped with a multispindle attachment, can simultaneously drill up to five holes of varied dimensions with an accuracy of 0.005-inch. Unit eliminates traditional process of manually laying out, checking, center punching and hand drilling of panel board holes.

New Data Processing Devices Expand Need for Old

ELECTRONIC devices for computing and data handling will open new fields and expand present methods and accomplishments rather than replace existing equipment, according to **Hugh L. Clary,** president of the Clary Corp. Existing equipment will be needed to feed information and receive instructions from the more advanced electronic computing and data handling devices. Clary's remarks were ocasioned by the opening of the Stanford Research Institute's Industrial Economics Conference.

In describing the long and short range planning for his own company's growth, Clary noted that his company is entering the field of factory automation in its own manufacturing processes on an increasing scale. He also noted that the abilities of present day electronic computing devices went far beyond the demand of hundreds of thousands of small businessmen, and that his company is developing electronic means of meeting their peculiar needs.

Machine Tool Financing

INSTALLMENT plan that will allow ten-year terms with payments geared to new depreciation schedules for machine tools is now offered by National Automatic Tool Co. Inc. The new financing program was worked out with C.I.T. Corp. and marks the first time NATCO has offered its machines on installment terms.

Kenneth Martin, vice president in charge of sales, said the company will offer three-year terms on an equal-monthly-payments basis. Terms to ten years will be offered

on a Pay-As-You-Depreciate plan under which monthly payments during any year of the contract will total approximately what can be depreciated that year under the new, faster depreciation schedules. Plan makes it possible for the machinery buyer to gain a realistic relationship between the provision for depreciation and the rate of payment for machinery.

Wave Distortion Eliminated With Regulating Device

NEW distortion eliminating voltage regulator has been developed by Electronics Div., Curtiss-Wright Corp. The device reduces the distortion of an ac sine wave to 0.3 of one per cent. This compares to about 3 per cent for current treated by standard refining equipment.

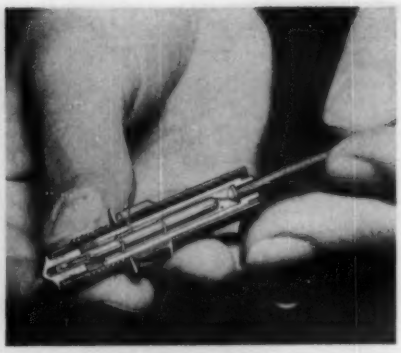
Regulator embodies a new concept to eliminate low frequency harmonics and noise, leaving a pure sine wave. The circuit taps the incoming wave form and obtains from it a sample representing all of the disturbances present. This signal is amplified and fed back into the line 180 degrees out of phase. As a result, the line noise and harmonics are cancelled, leaving only a relatively pure sine wave without a shift in voltage-current relationship.

This voltage regulator is particularly beneficial to analog computer installations and has wide applications in laboratories using electronic testing equipment; in the testing of low horsepower motors, meters and transformers; and in production setups requiring precise machine tooling.

Electric Motor Line Features Plastic Insulation

RE-ENTRY into the electric motor field has been announced by Lincoln Electric Co., Cleveland. The company has introduced a new line of "Linc-Weld" motors, available in standard sizes from 1 to 40 hp, which contain a unique extruded plastic insulation. The new thermosetting plastic insulation, unlike conventional varnish insulation which is applied by dipping, is molded into and around the stator windings. The motor stator is placed into a die and the plastic material is forced into the die under the proper heat and pressure. The liquid plastic resin is extruded through the stator slots, completely covering the stator winding. After the plastic resin "sets," the stator is removed from the die. The result is a motor winding that is encased in a rigid, tough and durable mass.

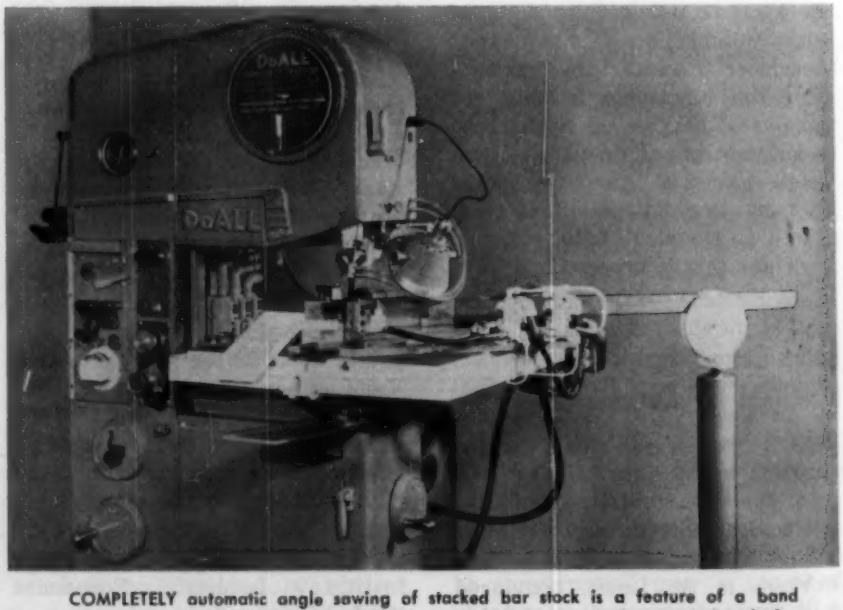
The plastic, in extensive field test, has demonstrated exceptional resistance to chemical action, humidity, abrasive dust, lint, and oil vapor. In applications that formerly required a totally enclosed frame, the motor has performed for a longer time than the totally enclosed motor it replaced.



NEW bearing overheat detector thermostat for industrial machine bearings and other equipment where an accurate overheat warning signal is needed has been developed by Vapor Heating Corp., Chicago. The metal housing contains an accurate vapor mercury contact thermostat which will detect overheat temperatures and light a warning signal in less than 4 seconds from the time that the overheat conditions take place. No amplifier, relays or bridge pickup box are needed with the device. In addition to bearings, the unit can be used to sense overheat conditions in gear boxes, universal joints, clutches, electrical generator or alternators, and in various aircraft applications.

Tape Standards Studied

RADIO-Electronic-Television Manufacturers Association has assigned a task group to formulate standards for punched cards and tapes used for control purposes. While no formal, joint RETMA-National Machine Tool Builders Association action has been taken as yet, many member companies of NMTBA are represented on the RETMA committee. Subjects studied to date include numerical control, template control, compatibility of systems, wide tapes, machining problems, equipment availability, data processing and computers.



COMPLETELY automatic angle sawing of stacked bar stock is a feature of a band machine developed by the DoAll Co. In operation, the stacks are indexed, hydraulic feed table moves forward on the cutting stroke, and finished pieces ejected automatically. Clamps and hold-downs are eliminated because of the constant downward pressure exerted by the cutting tool.

Russian Blueprint for Future Assigns Automation Key Role

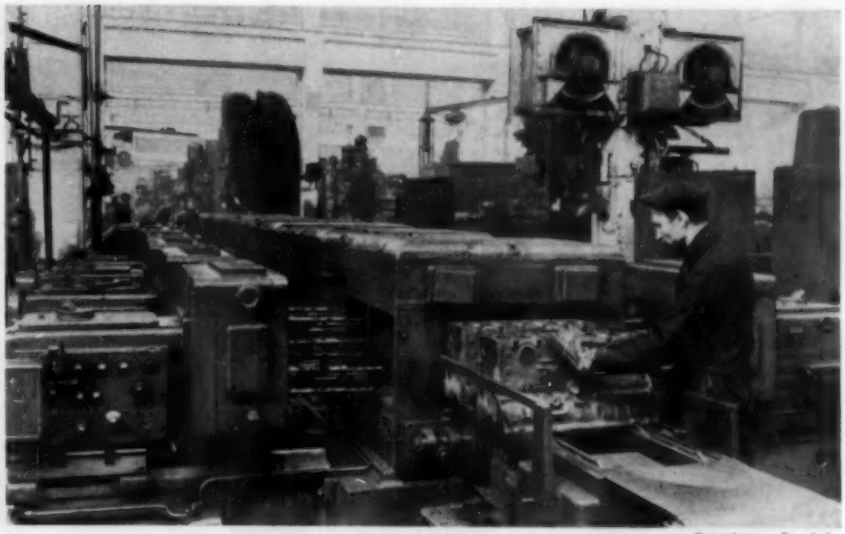
By A. J. Steiger

AUTOMATION is considered so important to the future of the USSR that state planning officials have been directed to draw up a special co-ordinated plan for nationwide use of modern automated processes in all industries. The directive is contained in the official Sixth Five-Year Plan recently announced in Moscow.

With an overall goal of boosting the nation's gross national industrial output 65 per cent by 1960, the authoritative party directives on the national plan show that "the means of automation" are listed among class *A* priority items, along with iron, steel, oil, coal and electric power. Some idea of the importance of automation to the Soviets can be gained from the data which indicates that these branches of heavy industry are scheduled for an overall expansion of 70 per cent during the next five years, in comparison to a target increase of 350 per cent in the manufacture of instruments and means of automation during the same period.

In establishing a base for more widespread application of automation, 30 new instrument factories are blueprinted for construction and opening before 1960. Research in instrument design and manufacture is being intensified to keep pace with the rapid march of progress in nuclear physics, radio technology and electronics. Output of problem solving computers is being stepped up. Wider use of semiconductor devices is scheduled.

The ambitious manufacturing program for "the means of automation" foreshadows its counterpart, an equally impressive plan for installation of automatic processes. The installation program embraces the whole Soviet economy. The directives state that with the object of furthering technical progress, raising productivity and easing labor conditions, industrial processes are to be mechanized and automated at a rapid rate and on an extensive scale. A major feature is the projected shift from automation of separate units and operations to automation of shops and technical processes, and the creation of fully automated plants. Some of the major objectives envisaged in the five-year installation program are:



Courtesy, Sovfoto

Picture of new automatic machine line which has been installed in the engine department of the Molotov automobile plant in Gorky. Engine blocks are being processed by the transfer machine. Two workers service the line.

Steel Industry — Establishment of 40 automated rolling mills for the production of pipes and other rolled metal is scheduled. Open hearth furnaces are to be put increasingly on the basis of automatic control; with blast furnaces more or less fully automated. Dispatching of underground traffic and remote control of basic machinery in the mine and on the surface is to be instituted at all large iron ore and manganese mines. Complex automation of operations is scheduled for ore concentrating plants of ferrous metallurgy.

Coal Industry — Plan calls for expansion of automation and remote control of machines and mechanisms in the mines and above ground, with utilization of powerful excavators at open pit mines.

Electric Power — Basic power systems and large substations are to be provided with remote control operating means during the next two to three years. All thermal electric stations, construction of which is launched during the Sixth Five-Year Plan, are to be fully automated.

Machine Building—Not less than 220 automatic and semiautomatic lines and shops are scheduled for installation during the next five years. This represents a five-fold expansion over the 40 automated lines presently operating in USSR plants producing motor cars, tractors and other machines. A priority rating is given to extensive automation of foundry and forge press operations.

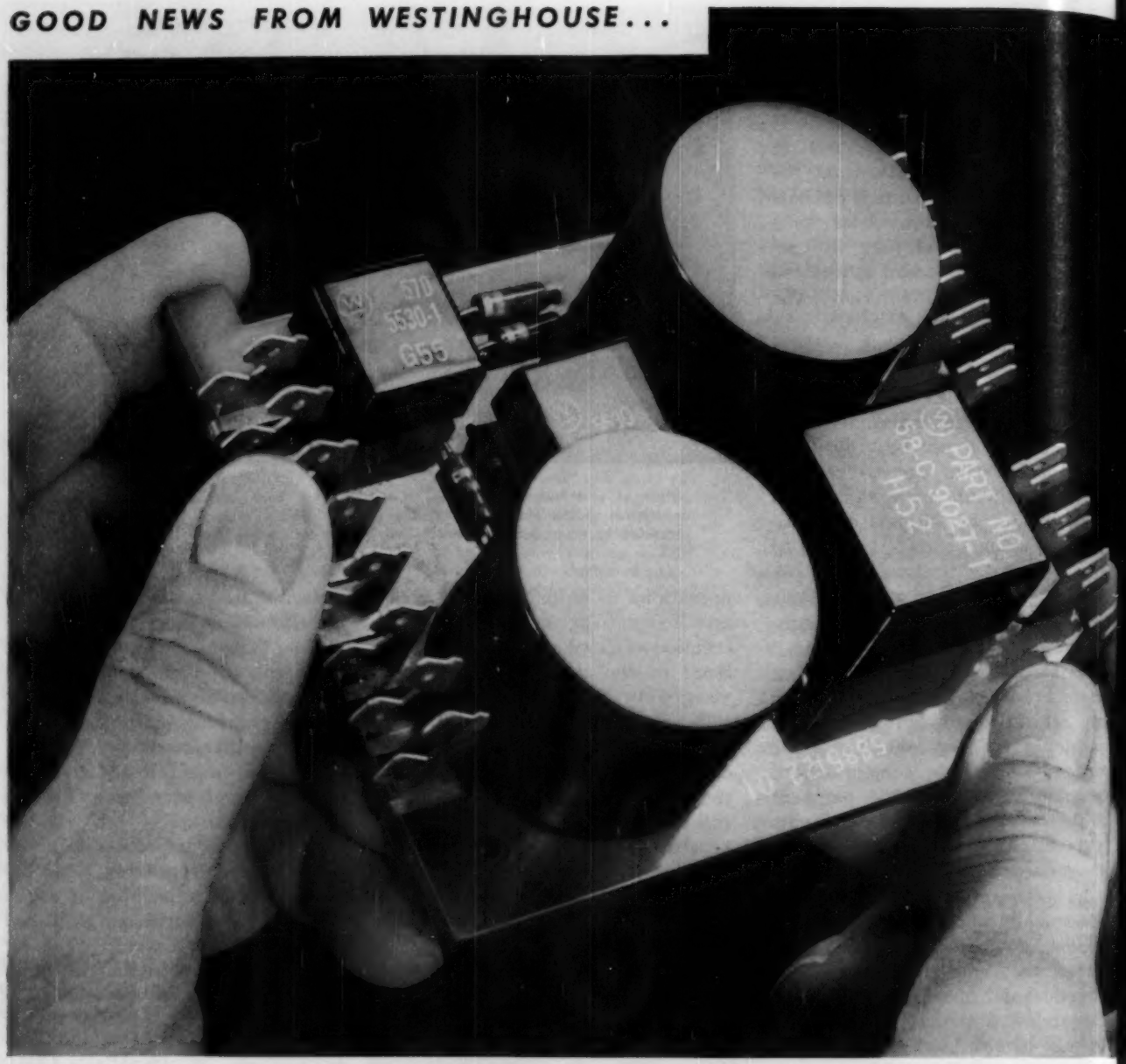
Electrical Equipment—Automation is to be introduced to motor assembly and production of cable. In radio set production, expanded mechanized processes are envisaged for the production of radio parts including vacuum tubes.

Consumer Goods—In the textile industry, the 1960 target is for 60 per cent of all weaving looms to be made automatic. Flow lines under automatic control are scheduled for the cloth finishing plants. Conveyor lines are foreseen for processing leather and producing shoes.

This brief survey of the Five-Year Plan objectives obviously shows that the Russian authorities are banking heavily on the promotion of automation throughout the USSR to increase industrial output.

The plan actually spells out for various commodities the percentage of total planned expansion expected to result from simply improving production processes. These figures range from a low of 12 per cent expansion in cardboard to 89 per cent in passenger

GOOD NEWS FROM WESTINGHOUSE...



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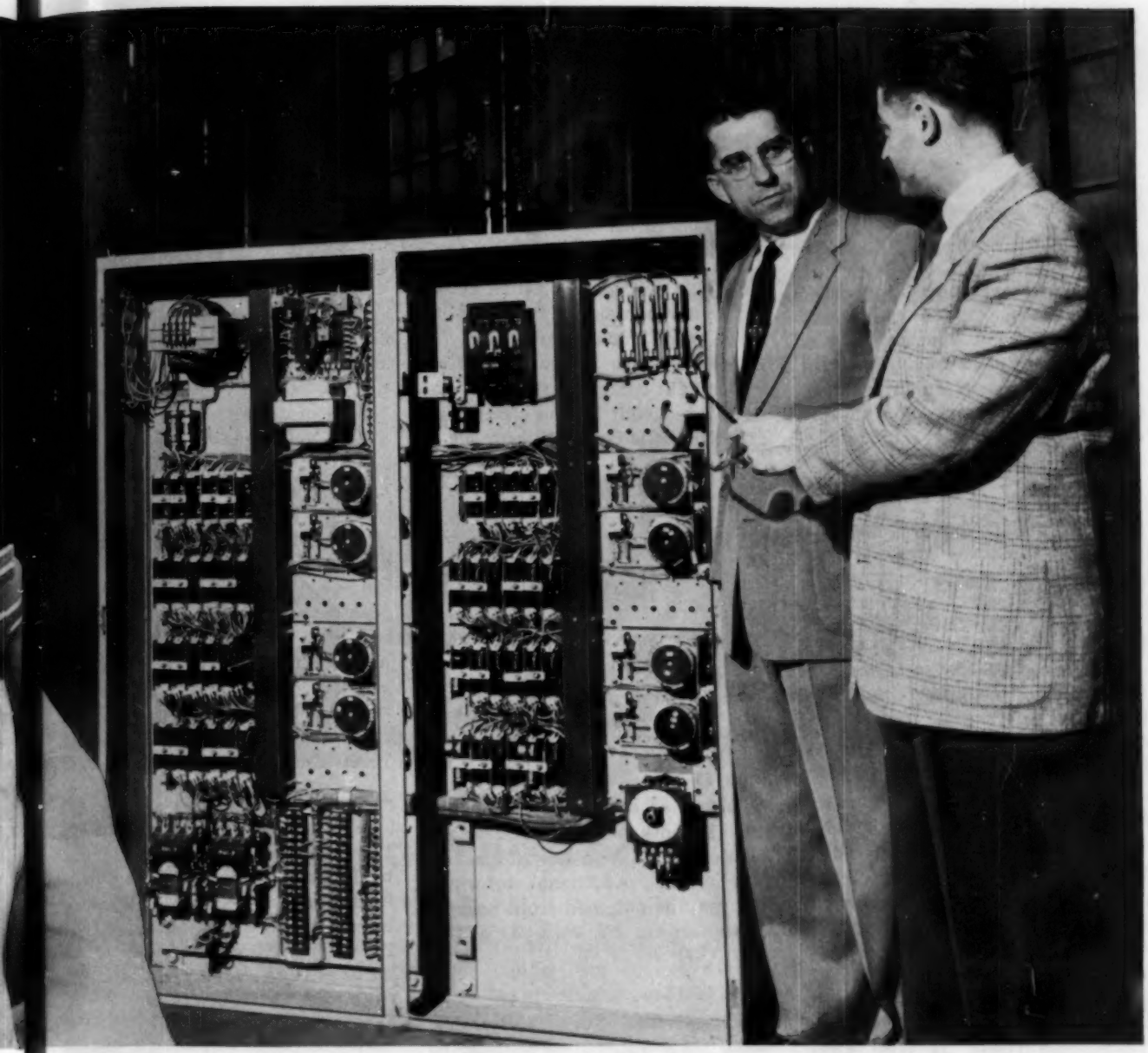

Just two years ago, production and control engineers alike dreamed of the possibilities of a relay with no moving parts. A reality today, Westinghouse CYPAK introduces static control from units that fit the palm of your hand. CYPAK control has no moving parts to wear, corrode, jam or otherwise cause failure. In addition, CYPAK refines the relay art through making use of basic logic functions.

The result—static control with life at least 15 times that of conventional relays. While twenty million open-close cycles is usually the maximum life of a mechanical relay, CYPAK systems can handle that many cycles in days without a trace of fatigue.

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* Trade-Mark

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Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa.

YOU CAN BE SURE...IF IT'S Westinghouse

car production.

These various figures are estimates based on the planned objectives as published in Moscow. And they cover only a random choice of industries. Whatever one may think of the figures, it is difficult to minimize the long range overall results which can be made with a special nationwide, co-ordinated plan for the introduction of automation into all industries. The recent observations of Russian industry made by American experts indicate that generally a gap exists between American and USSR practices. Nothing was observed which would indicate that this gap cannot be narrowed or closed.

Traffic Lights Respond To Varying Traffic Conditions

ELECTRONIC device which sends out radio signals is expected to help ease traffic congestion in Evansville, Ind. The unique radio traffic light control system was designed and built by the electronics division of the General Electric Co. A master controller located at City Hall stores a week's information on the most desirable traffic patterns for downtown Evansville.

Automatically every hour the controller codes into electronic tones information on the best traffic light pattern for that particular time. The tones are then transmitted via fm radio to radio receivers connected to each of 54 traffic lights in downtown section of the city. When a decoder at the individual light receives tones intended for it, appropriate relays are activated which change the length of time the traffic light is green, yellow and red.

MEETINGS AND EVENTS

May 14-17—

American Society of Mechanical Engineers. Design Engineering show to be held Convention Hall, Philadelphia. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

May 21-22—

Radio — Electronics—Television Manufacturers Association. Symposium on reliable applications of electron tubes to be held Irvine Auditorium, University of Pennsylvania, Philadelphia. Additional information may be obtained from Association Headquarters, 650 Salmon Tower, 11 West 42nd St., New York 36, N. Y.

May 23-26—

National Society of Professional Engineers. Annual meeting to be held Ambassador Hotel, Atlantic City, N. J. Additional information may be obtained from Society Headquarters, 2029 K St., N.W., Washington 6, D. C.

May 24-25—

Third Conference on Mechanisms. Sponsored by Purdue School of Mechanical Engineering and *Machine Design* to be held Purdue University. Additional information may be obtained from the Editor, *Machine Design*, Penton Bldg., Cleveland 13, O.

June 5-8—

Material Handling Institute Inc. 1956 Exposition to be held Public Auditorium, Cleveland. Additional information may be obtained from Institute offices, Suite 759, One Gateway Center, Pittsburgh 22, Pa.

June 11-15—

Society of the Plastics Industry Inc. Seventh national plastics exposition to be held new Coliseum, New York. Additional information may be obtained from Society Headquarters, 65 West 44th St., New York 36, N. Y.

June 11-15—

Pennsylvania State University. Small plant automation seminar to be held University Park, Pa. Additional data may be obtained from Extension Conference Center, Pennsylvania State University, University Park, Pa.

June 11-29—

Case Institute of Technology. Summer study course in process control theory with frequency techniques to be held Cleveland campus. Additional information may be obtained from Graduate Div., Case Institute of Technology, 10900 Euclid Ave., Cleveland 6, O.

June 18-22—

Human Engineering Institute. Fourth annual institute conducted by Dunlap & Associates Inc. to be held Stamford, Conn. Additional information may be obtained from Dr. L. W. Thomas, Dunlap & Associates Inc., 429 Atlantic St., Stamford, Conn.

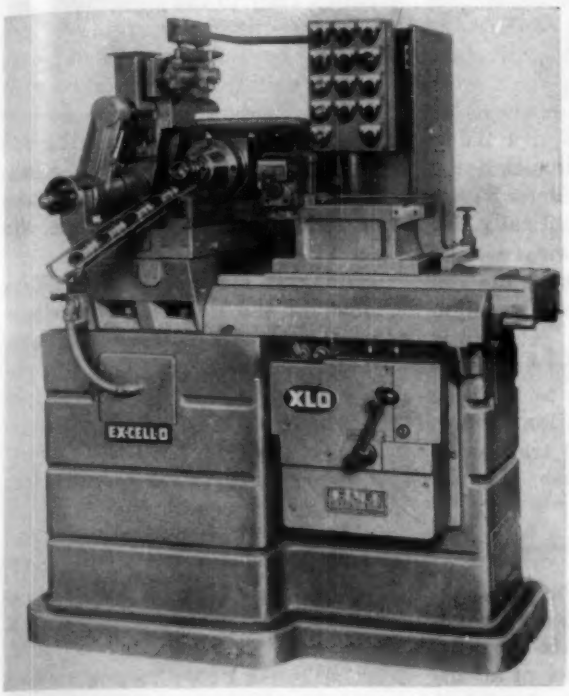
June 26-29—

International Congress on Cybernetics. Sponsored by Belgian Ministry of Education and UNESCO. Automation section under chairmanship of G. R. Boulanger of the Polytechnic Faculty of Mons and of Brussels University. To be held Namur, Belgium. Additional information may be obtained from Congress Secretary, 13, rue Basse-Marcelle, Namur, Belgium.

July 9-20—

Purdue University. Short course in linear automatic control system synthesis to be held Lafayette, Ind. Additional information may be obtained from Div. of Adult Education, Engineering Administration Bldg., Purdue University, Lafayette, Ind.

By JAMES C. KEEBLER
Associate Editor



Standard Ex-Cell-O style 2112-B precision boring machine equipped with additional components to handle the workpieces. Tooled to plunge-cut grooves in outside diameter lands on the illustrated steel sleeve for an automobile oil pump drive, the machine receives parts from transfer mechanism and delivers them to a conveyor leading to the next operation.

Automated Machine Tools

AUTOMAKERS' production planning consists in large degree of machine tool planning, for machine tools comprise a major percentage of the equipment used to manufacture automotive parts.

Basic thinking in this regard must always be built on considerations of cost. The cost decision with respect to machine tools is based on many complex factors: Original cost of the machine, including machine design engineering charges and machine construction costs; cost to tool the machine to handle the operation desired; cost to install and erect necessary service facilities, including electricity, air, hydraulic oil, water, coolant and chip removal provisions; cost to operate in production, involving number of full or part time operators, space rental, and utilities consumed; and cost to maintain in service.

Standard machine tools have traditionally offered advantages in original cost because the machine tool builder can spread his design engineering expenses over his expected sales volume. Standard machine tools are generally multi-purpose and provide flexibility to be retooled for other jobs.

Transfer Machines

As the special-purpose transfer machine grew in popularity in automobile production it became apparent that the combination of many different machining stations, linked by a transfer bar into one long straight line machine could provide savings in operating expense that would offset engineering costs. But this proved to be a two-sided coin.

Savings accrued by reducing the number of operator-hours required to machine a part can be eaten up by downtime of the whole machine when one station needs tool change or maintenance service. Subdivided transfer machines, that bank a supply of parts between their segments, were developed as an answer to this cost problem. This represents a compromise between one machine for the whole production sequence as one extreme, and one machine for each operation of the sequence as the other extreme.

Transfer machine manufacturers can provide equipment that will perform sequences of operations not possible by merely joining a series of standard machine tools. In purchasing such a machine the automaker avoids the liaison headaches that can accompany setting up a new line with equipment supplied by many sources.

The state of this art has been developed to the extent that a huge special-purpose machine is composed of standardized units. Standard spindle drives with standard slides on standard bases can be fitted with special heads with a minimum of engineering expense charged to the job at hand.

Economic advantages are realized by choosing the right combination of standardized units to perform the required operations. Each part to be processed is studied to determine the machine tool approach that will net the greatest cost advantage.

A cylinder block is of such shape and size that it can be shuttled between work stations without any auxiliary support. But many parts having a machining sequence that is natural for the transfer machine approach are not blessed with a configuration that lends itself to

being shoved between work stations and easily reoriented.

To accommodate these mavericks the machine tool designer provided pallets or sliding fixtures that position the part and "run the gauntlet" with it. This solution has its cost problem too. There must be as many fixtures as there are stations on the machine plus enough fixtures to fill the return conveyor supplying the operator at the loading station. Extra fixtures mean extra cost. As the blacksmith used to say: "It's not difficult to make one alike, but two alike is tougher." So with this type of machine the user must pay for a large inventory of identical, costly, precision fixtures.

Handling the Problem

Tool planning for automated production still involves the basic machine tool elements of a work station to hold and/or move the part during the operation, and a cutter station to support and/or move the cutter. Another major element has grown into the picture, and that involves handling the parts into and out of the work station.

In early days of production machine shops the machine tools were of the tool room type with an operator hand loading the workpiece, hand positioning the work table, and hand feeding the work slide or tool slide to make the cut. As machine tools were upgraded into automatic cycling machines the machine tool builders began to offer standard machines that would traverse, feed, return and stop automatically. No longer was the operator required to have the skill necessary to "find size." With the notable exception of the multispindle automatic screw machine these developments were devoid of devices to load the part into the work station remove it when completed and transfer it to the next work station.

Getting the Business

Recognizing that the business often goes to the bidder who will tackle the biggest part of the complete machining sequence of an automotive part, some machine tool builders were quick to set about designing handling equipment to offer with their machines. Others still stick to the idea that this part of the problem is someone else's baby.

It is clear to the production man, however, that the complete machining cycle involves handling the parts, and the same kind of ingenuity that relieved the operator of the drudgery of actuating and powering each phase of the machine cycle can eliminate the chore of hand loading to keep pace with the machine.

As the machine tool builders move in the direction of satisfying their customers' desires we see standard automatic cycling machines being equipped with standard handling devices. The magazine escapement, loader, and eject mechanism are timed right into the machine cycle.

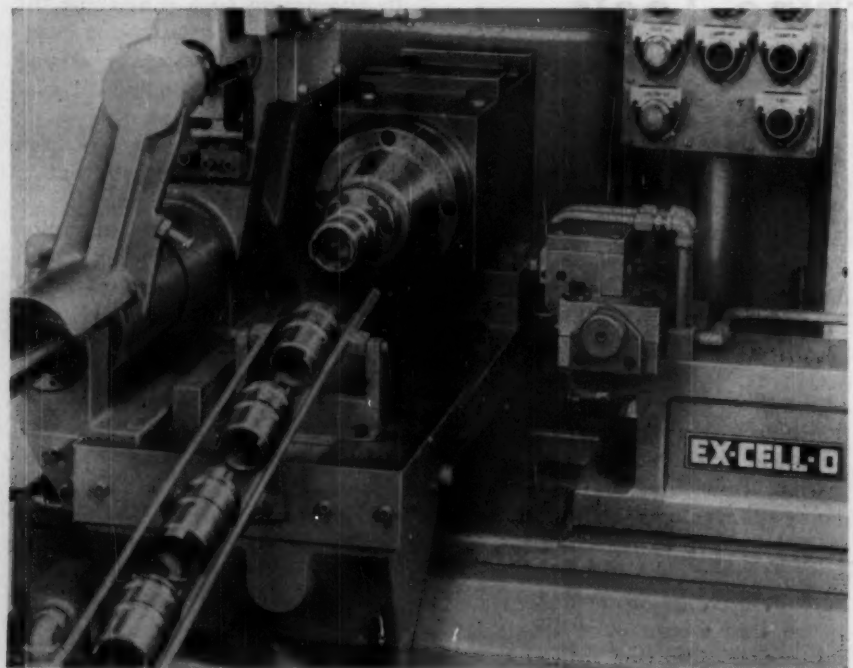
When such machines are linked together by storage banks, transfer mechanisms or conveyors, they provide the same effect as that achieved by subdividing a transfer machine. Retooling for another part involves new tools for the work station, the cutter station and the handling station. Certainly future developments will add the gaging station to this list.

Developments in this direction are appealing not only to the automakers who are looking for an ever increasing array of possibilities from which to make their machine tool choices, but appeal also to smaller companies looking for low cost opportunities to achieve a higher degree of automation.

Developing the Future

In a recent talk entitled, "What We Expect of the Machine Tool Builder," John J. Holmes of the General Motors Production Engineering Section threw the challenge out one step further and asked for standard machines for assembly operations.

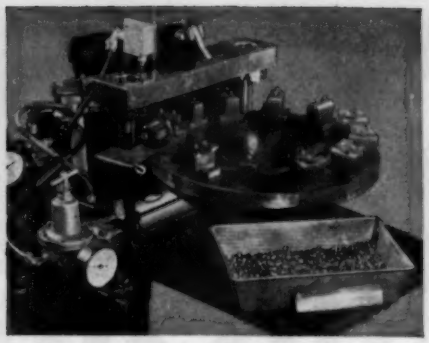
Industry looks to new and better machines to help reduce production costs. The field is wide open, the future will see considerable advance in integrating past conventional operations with new developments in mechanized assembly to gain a new approach to overall automatic production.



Closeup of work area of standard Ex-Cell-O boring machine. Arm on handling attachment at left removes part from magazine and inserts it in air-operated chuck. Tool slide moves in from the right and cuts two grooves. After slide retracts chuck releases and air operated push rod ejects the part. Chute shown was used for tryout. Automatic cycling machines can be linked by storage banks, transfer mechanisms or conveyors to achieve automatic production processes.

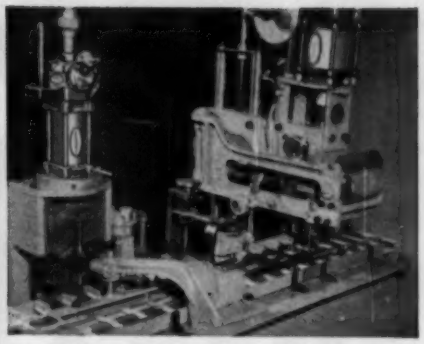
MACHINE FOR STRETCHING GIRDLE SEAMS CONVERTED TO FLUID POWER

PLANT SUPERINTENDENT: "I feel that the machine has paid for itself in the first month."



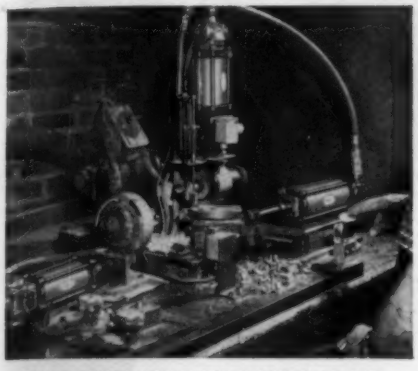
SPECIAL MACHINE PRESS-ASSEMBLES CHAIN SAW PARTS

PLANT OWNER: "Our savings in the first ninety days covered any expense we went to to make the change."



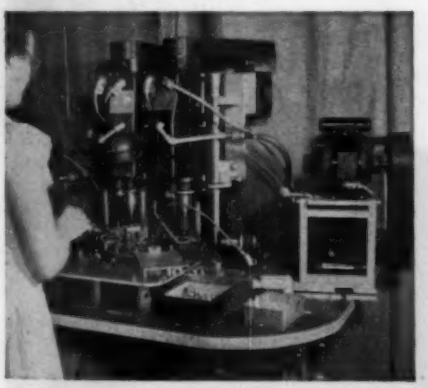
THREE OPERATIONS ON PLASTIC TOOTHBRUSHES COMBINED IN THIS FLUID POWER MACHINE

CHIEF PLANT ENGINEER: "It is policy with us that a machine must pay for itself within one year."



FLUID POWER MILLS THREE SURFACES AND DRILLS HOLE IN BAKELITE PART

PLANT MANAGER: "Very definitely has paid for itself in a very short period of time. We have effected savings amounting to about 300% . . ."



SEMI-AUTOMATIC FLUID POWER MACHINE DRILLS 4 HOLES IN FISHING REEL PAWLS

MACHINE ROOM FOREMAN: "Just as a matter of figures, we cut $1500.00 off the machine's cost in the first four weeks of production."

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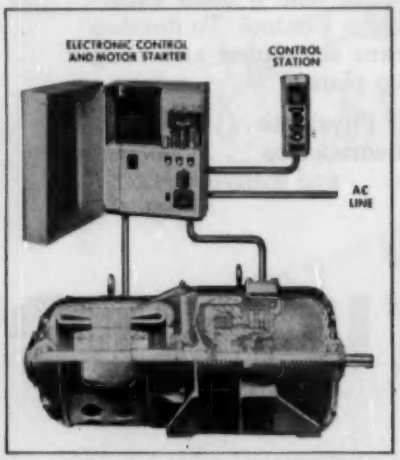
Dynamatic electronic controls with their simplicity, low maintenance, easy accessibility, and small space requirements, when used with Dynamatic Eddy-Current Drives, provide the solution to most adjustable speed drive problems.

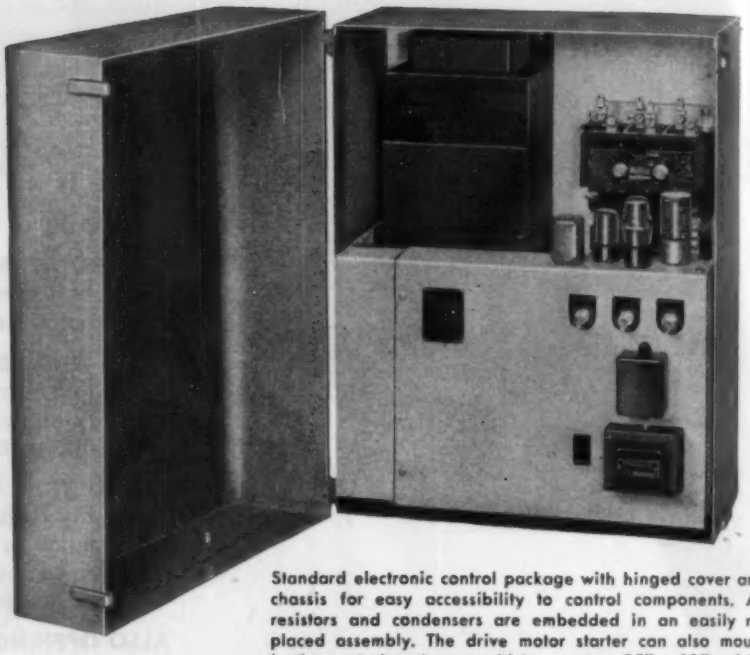
The excitation required by Dynamatic eddy-current equipment is of very small magnitude compared to the drive capacity. For example, a 440 watt control is capable of controlling the torque or speed output of a 400 HP drive. Control and excitation power is taken directly from AC lines without the need of cumbersome and complicated convertors, with their installation, ventilation, and maintenance problems.

Since the control elements have a very high amplification factor, even the largest couplings may be easily and conveniently controlled with small adjusting potentiometers.



The small illustration shows the minimum of typical components necessary to obtain adjustable speed with Dynamatic eddy-current equipment. Speed regulation requirements on the order of 1/10 of 1 per cent of drive top speed are easily and economically accomplished with suitable control modifications. With low powered reliable electronic components, requirements to suit almost all drive problems are easily met without appreciably increasing the cost or size of the control components.

The following outline of operation will indicate the many advantages of this Dynamatic control equipment.



Standard electronic control package with hinged cover and chassis for easy accessibility to control components. All resistors and condensers are embedded in an easily replaced assembly. The drive motor starter can also mount in the control enclosure, which measures 25" x 19" x 14".

Direct current excitation applied to the Dynamatic Drive coil modulates the strength of the magnetic fields and consequently, the amount of torque developed at any rate of slip between the rotating input and output members. So that the drive may satisfy load and speed demands, this direct current must be varied automatically.

Because of the drive's small power demands, rectification of easily available alternating current to direct current is a simple procedure. A gas-filled thyratron tube is all that is needed to accomplish the conversion from AC to DC. A rectifier used in conjunction with the thyratron tube, plus the highly inductive eddy-current drive coil, provides a smooth flow of direct current as required by the drive.

To obtain desired performance, a means of varying the amount of current to the drive coil must be provided. The thyratron tube provides this function in that the grid of the tube, influenced by an AC rider wave imposed upon the DC grid voltage, permits a smooth change in drive coil voltage from zero up to the available maximum.

A permanent magnet alternator, driven by the output shaft of the Dynamatic Drive, generates a voltage in direct proportion to speed. This voltage directed to the electronic control is utilized to maintain pre-set speed. With a reduction in load, speed tends to increase, but the generator signals the control so that the drive coil current decreases, slowing down the unit. Conversely, should the load increase, the drive tends to slow down so that the generator signal to the electronic control automatically increases the current, permitting the drive to return to the pre-set speed.

Speed and load (current) control are two of the standard types of electronic controls available. Because of the almost unlimited uses and adaptations of electronic components, many operations can be conveniently controlled, such as tension, acceleration, braking, threading, jogging, speed matching, and many others where an electrical signal can be fed to the control equipment.

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Unknown Today

In studying automation possibilities for any product, today as never before, it is important to know something of the future market prospects. The growing variety and growing complexity of products make it imperative to study manufacturing and market trends for future planning.

Some idea of the explosive pattern of market and technological expansion is revealed by a recent General Electric study concerned with electronics. In a talk before the American Ordnance Association, George F. Metcalf brought out the fact that a third of the electronic products available in 1965 will result from technology unknown and unsuspected today. The study showed that the developments of each decade contribute about twice as much as those of the preceding decade. Basic new knowledge is acquired and used at a constantly accelerating rate to establish new services and products—resulting in greater product complexity and also in shorter product life before reaching peak use.

These characteristics are significant, says Mr. Metcalf, in that they reflect "the future of all growing fields of science and technology." And "the primary steps in this continuously accelerating growth of knowledge are made by products and services requiring increasingly larger amounts of diversified human effort for their successful development and production."

These facts carry singular impact in planning for automatic operations. The explosive growth of technological developments to be experienced in the next decade presents an outstanding challenge to industrial management. It will require intensive market research, increased product development and design, better automation engineering and keener management co-ordination of effort to be really ready for the future.

EDITOR

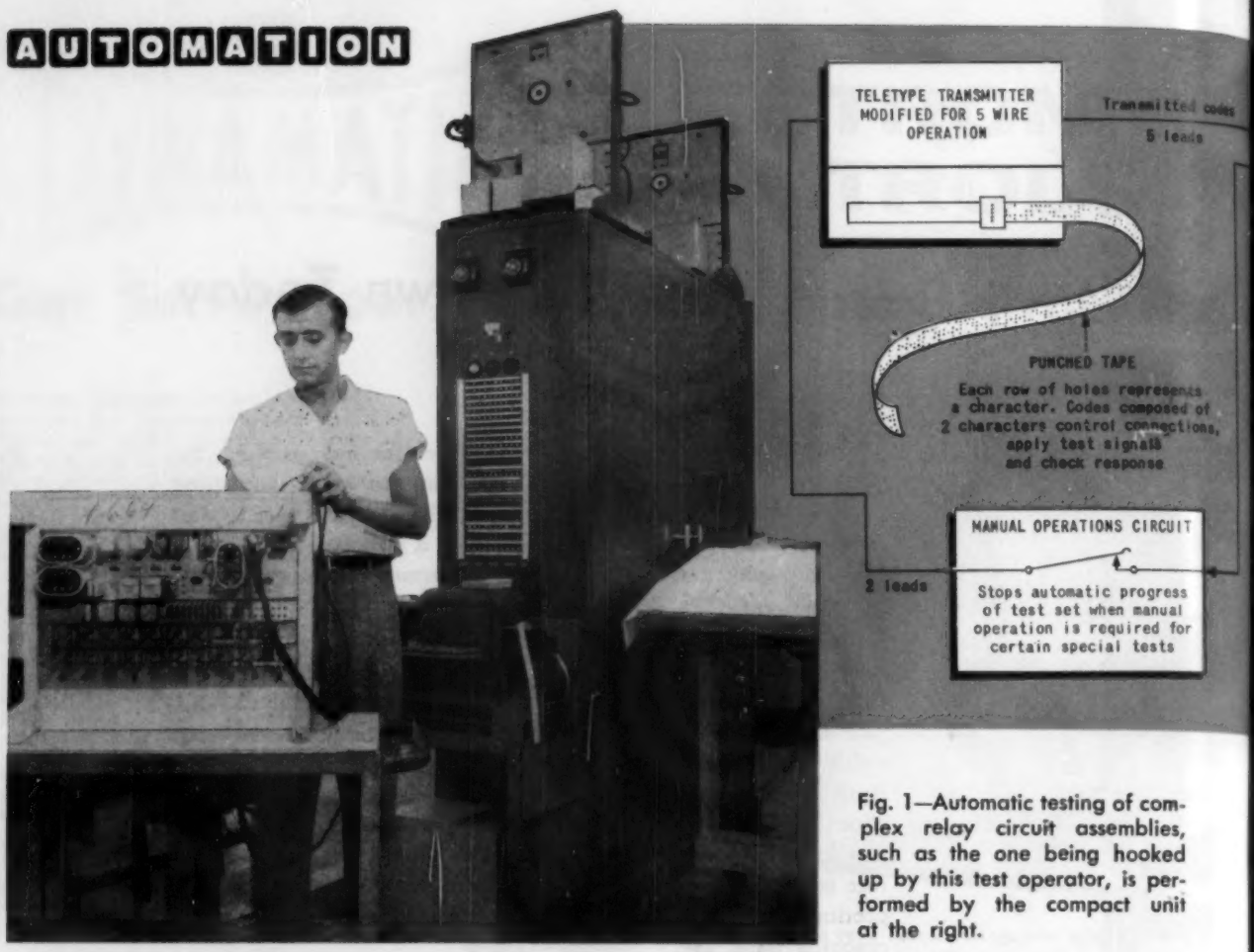

TELETYPE TRANSMITTER MODIFIED FOR 5 WIRE OPERATION
Transmitted codes
5 leads
PUNCHED TAPE
Each row of holes represents a character. Codes composed of 2 characters control connections, apply test signals and check response
MANUAL OPERATIONS CIRCUIT
2 leads
Stops automatic progress of test set when manual operation is required for certain special tests

Fig. 1—Automatic testing of complex relay circuit assemblies, such as the one being hooked up by this test operator, is performed by the compact unit at the right.

TAPE CONTROL

IMPROVES CIRCUIT TESTING AND CUTS COSTS

By L. D. HANSEN
Department Chief
Switching Apparatus and Equipment Test Set Development
Western Electric Co. Inc.
Kearny, N. J.

Typical of problems where complexity of design and volume of production make manual procedures inefficient and inadequate, this manufacturing inspection operation was successfully answered by development of automatic test sets controlled by punched tape.

MANUFACTURE OF large and complex communication systems requires versatile and efficient methods for production testing of unit assemblies. In the case of telephone switching equipment, Western Electric Co. makes a large variety of shop wired relay unit assemblies which must be tested prior to shipment for installation in telephone central offices. Ordinary manual testing procedures for each relay unit would be time consuming and the circuit complexity and monotonous nature of the tests would naturally lead to human errors.

With these factors in mind, Western Electric decided to develop and build test sets to automatically perform as much of the testing on the relay units as practical. The result was the Tape-O-Matic Test Set[1] designed to automatically test these relay units in a few minutes. All that is

[1]Patent No. 2,328,750

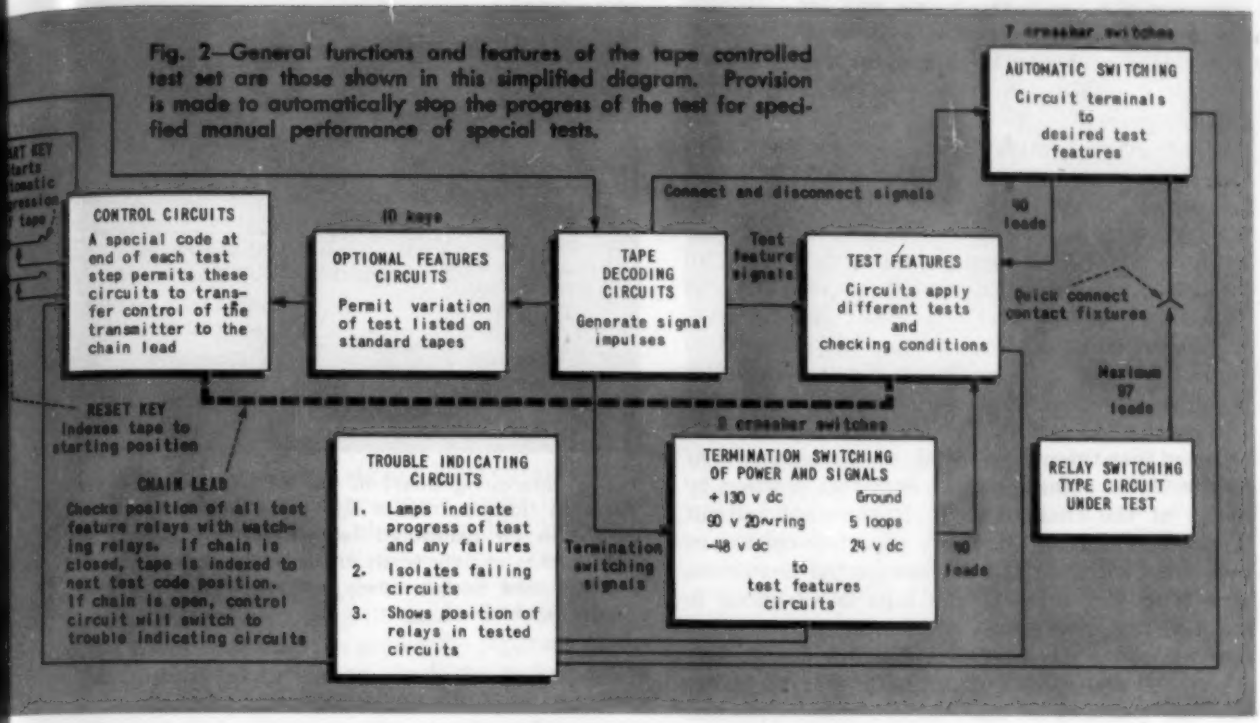

7 crossbar switches
AUTOMATIC SWITCHING
Circuit terminals to desired test features
Connect and disconnect signals
40 leads
CONTROL CIRCUITS
A special code at end of each test step permits these circuits to transfer control of the transmitter to the chain lead
10 keys
OPTIONAL FEATURES CIRCUITS
Permit variation of test listed on standard tapes
TAPE DECODING CIRCUITS
Generate signal impulses
Test feature signals
TEST FEATURES
Circuits apply different tests and checking conditions
Quick connect contact fixtures
Maximum 97 leads
RESET KEY
Indexes tape to starting position
CHAIN LEAD
Checks position of all test feature relays with watching relays. If chain is closed, tape is indexed to next test code position. If chain is open, control circuit will switch to trouble indicating circuits
TROUBLE INDICATING CIRCUITS
1. Lamps indicate progress of test and any failures
2. Isolates failing circuits
3. Shows position of relays in tested circuits
Termination switching signals
8 crossbar switches
TERMINATION SWITCHING OF POWER AND SIGNALS
+130 v dc
Ground
90 v 20-cy ring
5 loops
-48 v dc
24 v dc
to test features circuits
40 leads
RELAY SWITCHING TYPE CIRCUIT UNDER TEST

Fig. 2—General functions and features of the tape controlled test set are those shown in this simplified diagram. Provision is made to automatically stop the progress of the test for specified manual performance of special tests.

required is a coded length of perforated teletypewriter tape that contains all the information required by the machine to select proper terminals, apply proper voltages and verify circuit operations in any combination or sequence desired. The tape is inserted into the test set, quick coupling contact fixtures are attached to the unit, a button is pressed and the test is under way. If a circuit does not meet requirements, the test set stops and lights indicate the nature of the trouble.

One way of looking at this test set is to regard it as a flexible semi-automatic control machine with response indications. Dial telephone systems constitute by far the largest part of automatic digital control equipment in the world at present, and the Western Electric Co. makes such dial telephone equipment. This point is emphasized here because reliable components were available that could be used in this test set—the main ones being standard Bell System relays and crossbar switches.

It is not necessary to dwell too long on the need for reliability in the test set, but it may be interesting to recount the capabilities and ruggedness of the main components. The set uses 430 relays, each having a multiplicity of circuit contact springs. These relays have, over the years, been required to perform reliably millions of times before replacement. Nearly all contacts are bifurcated, thus putting two contacts in parallel for reliability. Nine crossbar switches, which are switching mechanisms consisting of rectangular fields of 200 sets of contact springs operated by co-ordinated horizontal and vertical magnetic coils, are the terminal selecting components of the set.

The switching and associated apparatus is housed in a metal cabinet 20 inches wide, 66 inches deep and 84 inches high. At one end of the cabinet are the signal panel, multicontact receptacles for connection to the relay unit under test, and a shelf to support a Teletype tape unit. A test set, with its associated power supplies mounted on top, is shown in *Fig.* 1.

▶ Principles of Operation

Some understanding of the operation of the test set may be gained from the block diagram in *Fig.* 2. The five possible coding perforations in each crosswise row on the tape use the teletypewriter code as a matter of convenience to represent 32 different characters in coding and preparing the tape. The 32 characters are combined in pairs to form two-character codes, and of the combinations possible, 521 are used. The coded tape is arranged for a number of testing steps, the number depending on the complexity of the circuit being tested. Each step contains a number of two-character codes to set up connections, connect power and signal terminations, apply test conditions and check for circuit response. There is one two-character code to establish a connection and another to disconnect it. In addition there is one two-character code to release all connections. The Teletype transmitter is arranged to read ten characters per second and transmit intelligence from all five hole positions in the tape simultaneously instead of sequentially as is normally done. Tape decoding circuits store the impulses from the

first character of a two-character code until the impulse from the second character is received. Both characters are then decoded and impulses sent to the associated circuits as indicated in the block diagram, *Fig.* 2.

After every testing step, a testing position code is used to permit a control circuit to transfer control of the transmitter to a chain circuit. This is a special circuit that checks the response of the test features circuits to determine that all expected test conditions have been satisfied and that no unexpected conditions exist. The test features circuits have signal relays that are used to check responses from equipment being tested. For each *signal relay* there is an associated *signal watching relay,* which "watches" or checks the expected condition (operated or unoperated) of its associated signal relay at each test position by means of the chain circuit. It the chain circuit is closed (meaning that all expected conditions have been satisfied and no unexpected conditions have been encountered) the tape is advanced to the next test. Otherwise, the control circuit takes over and puts the trouble indicating circuit into action. The simplified diagram in *Fig.* 3 shows how the position of the "watch" relay, operated or unoperated, must match that of its associated signal relay in order to provide continuity in the chain circuit. The fast or slow ground pulses cause the associated trouble lamp to flash at a corresponding rate to indicate whether the trouble is due to failure to meet an expected or an unexpected condition.

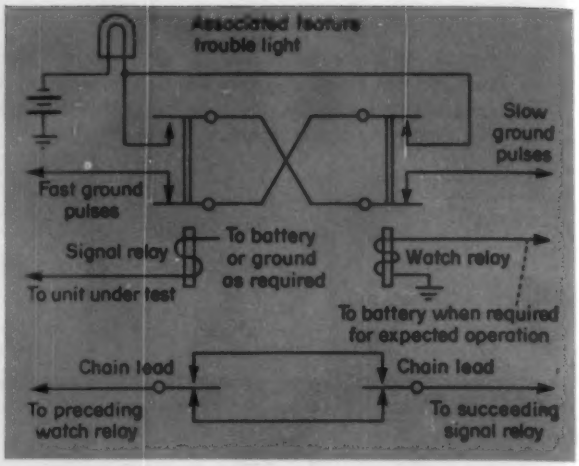


Fig. 3—Interesting detail in the set design is the provision to flash a trouble light to indicate nonconformance in an associated feature of operation. The light flashes rapidly when an expected response is not received and flashes slowly when an unexpected response is obtained.

▶ Test Circuits and Ranges

Any wired switching type unit having not more than 97 terminals can be tested by this set. In any desired sequence the terminals may be connected, disconnected, and reconnected to the 40 test circuits, some of which provide more than one test function. The test circuits are arranged for the following test functions: 17 direct connections for supplying power or multiple terminations, 1 high sensitivity (1 ma) relay circuit, 2 medium sensitivity (8.5 ma) relay circuits, 10 low sensitivity (21 ma) relay circuits, and 10 miscellaneous circuits. The ten miscellaneous test circuits perform several functions among which are included:

1. Sending and receiving ringing currents.

2. Sending and receiving dial pulses up to a maximum of ten.

3. Sending and receiving audio (600 cycle) tone for the purpose of checking talking circuits involving transformers and condensers where dc continuity is not present. By control of both the sending amplitude and the receiving sensitivity in discrete steps, an elementary transmission loss checking circuit having the following ranges in 600 ohm impedance circuits is available: 0.5 db or less, 0.5 db to 1.5 db, 1.5 db to 6 db, and 6 db to 15 db.

4. Checking marginal current relay operation by inserting a resistance variable in steps of 10 ohms up to a maximum of 24,850 ohms.

5. Using the variable resistance circuit as one arm in a relay operated Wheatstone bridge for checking resistance values.

In addition to the features mentioned, a frame ground checking circuit is provided. In telephone systems the ground leads of the talking and signalling circuits are ordinarily brought back to the fuse board in order to prevent crosstalk and interference from switching transients due to common ground impedance coupling. Since an inadvertent cross of the metal frame to a circuit lead might not show up in operation tests, a special circuit is incorporated to detect this condition.

The 17 direct connections referred to include power voltages and loop circuits commonly used in telephone offices and are available for connection to any test circuit. They include the following: 130 volts positive dc, 24 volts negative dc, 48 volts negative dc, ground, 90 volt 20 cycle ac ringing, 77 volt ringing with superimposed positive or negative 44 volts dc, and five loop or multiple circuits for common connections.

▶ Operation Details

Coding The Tape: Some of the details of the test set might best be brought out by reviewing typical operations. First, current orders for relay units are checked against a card file by a clerk to see if tapes are available for testing them. Due to the fact that telephone equipment varies, some special orders come in on which tapes are not available. In addition, most units have optional circuit arrangements which may be specified to take care of peculiar or individual service conditions in a telephone central office. These arrange-

ments are designated as lists in the specification drawings. In these cases, use is made of the optional features circuit which permits the setting up of as many as ten different combinations of optional list conditions. Ten pushbutton keys, visible in *Fig.* 4, are provided to allow the tester to preselect the optional tests in accordance with the individual job order. The portion of the tape not applying to the list conditions specified does not control any test functions and the chain circuit will not hold up its progress. When a new unit is to be manufactured for the first time a test engineer studies the circuit and plans a testing sequence which he lays out in two-letter codes on a conveniently arranged form. A clerk then punches the tape using a special teletypewriter setup.

In the planning of a tape, the engineer frequently finds that some signals have parallel paths through the circuit. Since these paths terminate on the same pins, it is obvious to him that only one path needs to work to pass the test under ordinary procedure. In order to be sure that all paths are present, he will insert a code on the tape which will stop the automatic progress of the test so that the tester can check the various paths manually. Or, more often, he will have test leads attached to terminals in the circuit and code the test for automatic processing. Other manual operations can be performed as required by the instructions associated with the tape.

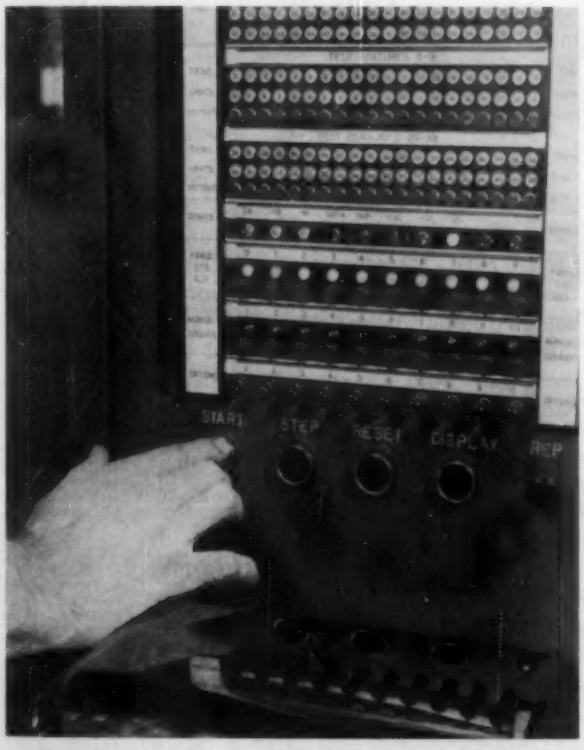


Fig. 4—After the terminal connections are made and the proper punched tape inserted in the Teletype unit, the test set automatically progresses step by step through the complete testing program unless it is stopped by a trouble response or a preset signal for optional manual tests.

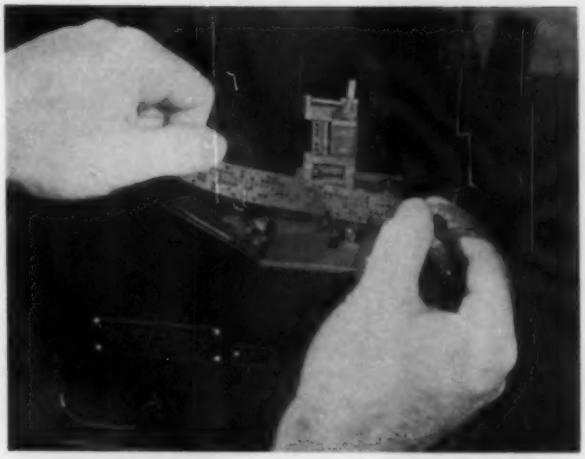


Fig. 5—Tape used to control the test set is standard punched paper tape such as used with teletypewriters. Control information is punched in the tape using 521 codes based on 32 character representations. Each code is composed of two characters which are simultaneously translated into control impulses.

Operating the Test Set: The operator obtains the proper tape, which has been coiled up and stored in a cardboard carton. The label on the carton contains all the setting up and operating instructions which he needs. Supplementary ohmmeter and continuity checks, internal circuit clip connections, optional circuit pushbutton selections and manual operations to be performed when indicated by the test set lamp display are typical instruction points. The test operator needs no other information to test or clear trouble except the schematic circuit of the unit under test.

The operator also selects and hooks up a multiconductor test cable terminated at one end with a contact fixture designed to fit the particular type of terminal strip used and the other end with a gang plug arranged to plug into the test set connector box as shown in *Fig.* 1. After a relay unit has been connected to the test set, the coded tape is inserted into the transmitter which translates the punched holes into electrical impulses, *Fig.* 5. The tape is driven by a feed wheel with pins that engage a continuous series of sprocket holes.

Actuation of the *Reset* key permits the control circuit to advance the tape to the starting position. This *Reset* key is also operated after the test set has timed out for trouble. The *Start* key is operated to begin the testing steps. The codes on each testing step then control the switching operations, selection of test features, signal voltages, options, and other functions preparatory to checking continuity through the chain circuit. Testing proceeds in this manner until trouble or malfunctioning is encountered.

Trouble Condition: When any test relay detects a trouble condition, as indicated by an open chain circuit, another relay cuts in which: (a) Sounds a gong, (b) opens the advance path of the trans-

mitter, (c) operates corresponding indicating lamp circuits, and (d) causes the trouble indicating circuit to indicate the "should be" position of any relay in the circuit under test up to 35 relays, thus facilitating trouble shooting by localizing the portion of the circuit having faulty operation. Each testing step as coded in the tape is sequentially numbered and in the event of stoppage for trouble, numbered lamps will indicate the step in question for easy checking against the original coding sheets.

Another valuable trouble shooting feature is the use of display pushbuttons located on the shelf just in front of the tape transmitter. Two different sets of buttons are provided, one directly associated with the test features in the test set and the other with the terminals of the circuit under test. Assume that the tape progress has been stopped for a trouble indication and a particular test feature lamp is flashing rapidly to show that an expected response was not obtained. The operator does not know, at that point, the terminal of the circuit to which that test feature is connected so he pushes the associated button to obtain that information from the lamp display panel. Or if he is working from the circuit terminal end, he can push a button associated with any terminal to find out which test feature is connected to it as well as what voltage or signal supply is in use.

End of Test Code: The last two letters on each tape are always the same, and signify the end of the test. At this point, if the test has occurred without trouble indications, the start relay removes the ground for advancing the transmitter and the tape stops indexing. However, if the test was stopped for trouble, the tape is re-run on the relay circuit to be certain that no new troubles have been introduced when the circuit repair was made.

Application History

Tape-O-Matic Test Sets have performed a magnificent job for several years. Like most complicated machines, they require understanding and proper care. Maintenance has been low considering their complexity—each set involves over 20,000 soldered connections. They are largely self checking through the use of strapped terminating plug connectors and 18 specially coded test tapes arranged to give indications of the internal operation of the set on the lamp display panel. Periodic checks are made using the test tapes to forestall possible undetected deterioration of relay operation or circuit performance.

The magnitude of Western Electric's relay unit testing operations may be judged by the fact that there are 20 of these test sets in the Kearny, N. J. shops and two in the Lawrence, Mass. plant. Over 1700 coded tapes are in active use. The test sets have tested a million or more relay units, a prodigious undertaking viewed from any standard. They have made testing easier, therefore reduced errors. They have prevented damaged units which might be caused by human testing, thus the quality of the product has been maintained; and from the standpoint of our customer, the Bell Telephone System, they have helped to reduce costs.

Control Medium Characteristics of Punched Tape

For many applications requiring automatic input of control data, 5-unit punched paper tape makes an ideal control medium because of one or more of the following attributes:

Simplicity and Reliability: Because of the high intensity of the signals generated, electronic control equipment is not required. Instead, mechanical control devices can be employed. Maintenance may be simplified and handled by less specialized personnel. Running test schedules to make sure apparatus is functioning correctly—common practice with electronic equipment—is not necessary with a mechanical setup.

Ease of Tape Preparation and Revision: Tape preparation is simply a matter of keyboarding, on a standard typwriter-like instrument. Correction is facilitated by the fact that the code combinations in the tape can be checked visually. Accurate revisions can be made simply by deletion or by replacing a section of the tape. Particular code combinations and sequences are readily located, and paper tape can be spliced.

Ease of Identification and Handling: Aside from the fact that the code hole combinations are visible and legible, the tape itself can be written upon; this is a help in insuring that the correct tape is selected and that tape is fed into the reading device properly. It should also be mentioned that paper tape will withstand considerable handling without becoming damaged.

Accuracy: Paper tape is unaffected by surface faults, such as pin holes or raised spots. There are no magnetism problems, which could result in accidental loss of control intelligence. As long as punched tape has sustained no visible damage, such as torn perforations, accurate signals in the correct sequence will be read out.

Control Precision: Punched paper tape can be stopped within the space of one signal.

Commercial Availability of Tape Originating, Reading, and Reproducing Equipment: Standard units of telegraph apparatus may be purchased or leased, or other common language tape equipment can be used.

Low Cost: Both the paper tape and the common language code perforating, reading, and reproducing equipment are relatively inexpensive. There is the further possibility that apparatus already in the plant for communication or data processing purposes can be made available in idle periods for tape preparation, obviating a new investment and servicing problem.

Transmission Feature: Information carried on 5-unit punched paper tape can be transmitted over private wire or exchange telegraph facilities without conversion. This can be an extremely useful feature, particularly in multiple plant operations.

Courtesy of Teletype Corp.

1

This machine slits wide rolls of board stock into narrow strips used for matchbook covers by Universal Match Corp.

AUTOMATION TODAY

MATCHBOOK MANUFACTURING

TECHNICAL DEVELOPMENT of high-speed special-purpose automatic machinery for manufacture of a given product, in many cases predates the use of the word automation, yet illustrates clearly the fundamentals of automation that are presently being applied on a broader industrial scale.

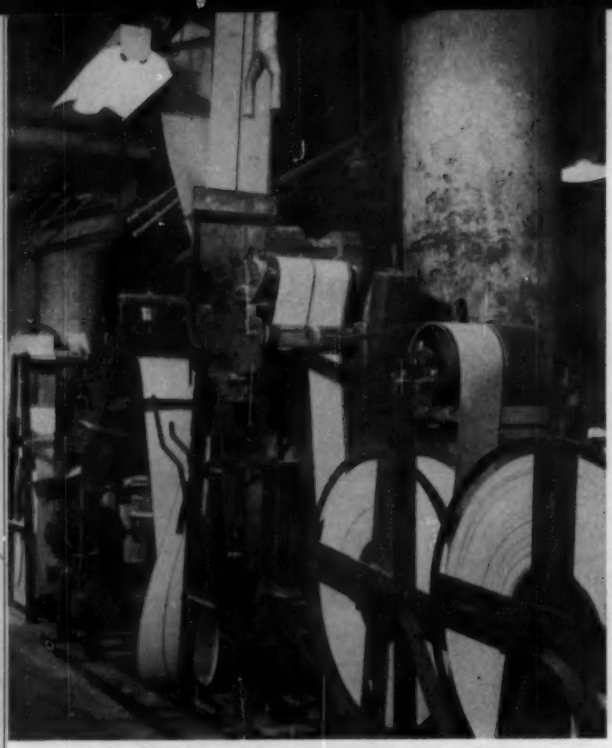
There is a growing awareness that these special-purpose developments have applications elsewhere and that certain common denominators of automatic machinery requirements can be handily served by common solutions. The Universal Match Corp. has utilized this awareness as a cornerstone in their diversified business activities. The principles of operation of equipment that makes matchbooks have been successfully applied to: Gun loading equipment made by their armament division, candymaking and packaging equipment used by a subsidiary candy company, and basic assembly machines and intermittent motion mechanisms offered to industry-at-large by a subsidiary machine and tool company.

The matchbook industry, which has become a major industry in the United States, is comparatively young. It was only sixty years ago that a Philadelphia lawyer, Joshua Pusey, patented the first matchbook which he assembled himself in a home workshop. Regarded at first as a novelty, rapid market development took place when matchbooks—regarded today as an almost indispensable commodity—became an instrument for advertising.

It was apparent from the "first steps" taken by the matchbook industry in its very infancy that prolific production of product, required to meet the evergrowing market, demanded the development of special high-speed automatic machinery.

The dearth of such equipment among manufacturers of machinery to whom inquiries were made and the urgency of this need, resulted in the major matchbook companies taking such development into their own hands if they wished to stay in business and meet deadlines for deliveries and marketing dates set by their customers.

The Universal Match Corp. entered the field less than thirty years ago. Competition in this new industry has always been keen, even from the very start and the success of a company depended upon the improvisation of automatic machinery accompanied by increased speeds of production. These two factors were basic "musts". A match company had to maintain low costs, while con-

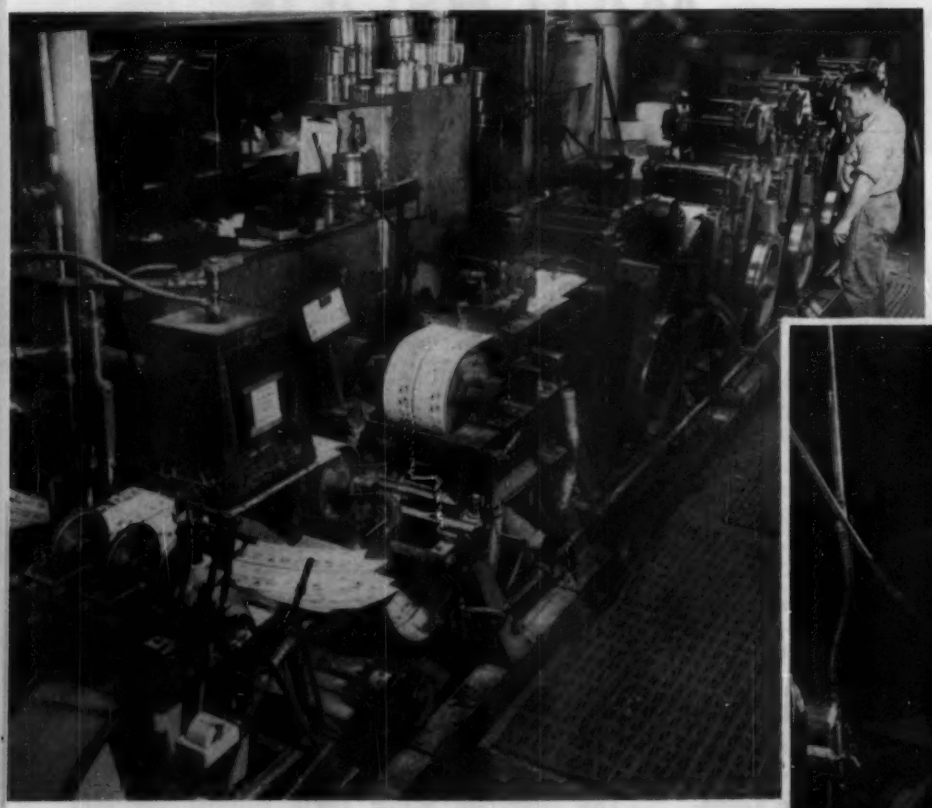


2 Composition striking strip is applied to the cover stock. Drying room is located at the rear. Finished material is wound on coils in the foreground.

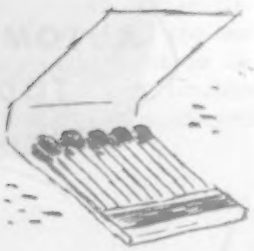
stantly improving the quality of its matches and the printing of its covers, in order to exist.

The necessity of using high speed in automatic machines led to intensive studies of the kinematic properties of various mechanisms and the possibilities of controlling the dynamic forces generated at higher speed. It was only by solving these problems that the manufacture of matches and covers on the vast scale we know today, became possible, and made matchbook manufacture a production achievement. One match machine can produce up to 30,000 matches per minute. Assembling machines have been developed which can cut, fold, stitch, and stack match books at the rate of 8 books per second.

In solving the problems of matchmaking, Universal engineers came up with a by-product, an intermittent motion mechanism now known commercially as the Ferguson Roller Gear Drive. The adaptability of this gear drive led to its acceptance by many other industries that were looking for such a device in the conversion of their own manufacturing processes to more automatic operation.



3 Matchbook covers are printed on this high-speed multicolor press line.



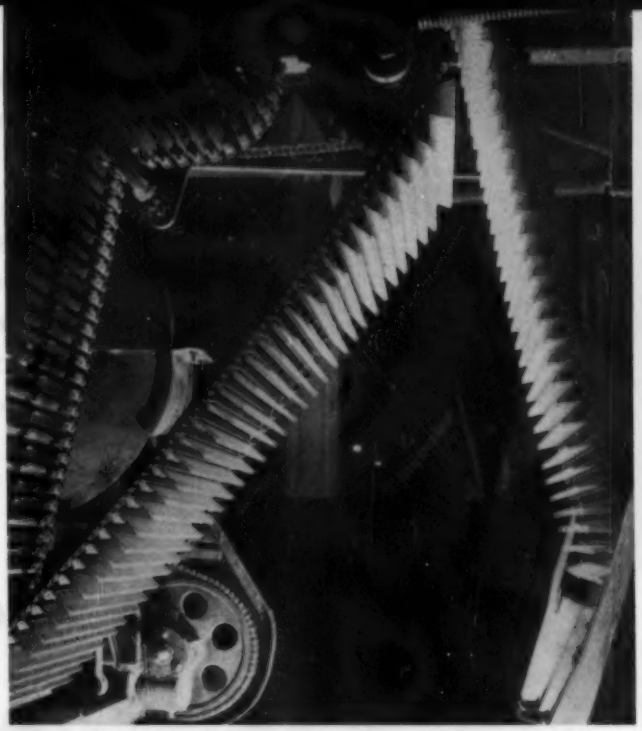
4 Cover material is laminated with acetate film on this automatic machine.

With the increase in population of recent years and the subsequent greater volume of production required of most industries to meet the needs of this growth, even greater automatic machine development has ensued. The matchbook industry was one of the first pioneers in this field and the results of matchbook experimentation gave growth to some of the present development of high speed techniques in automatic machine operation.

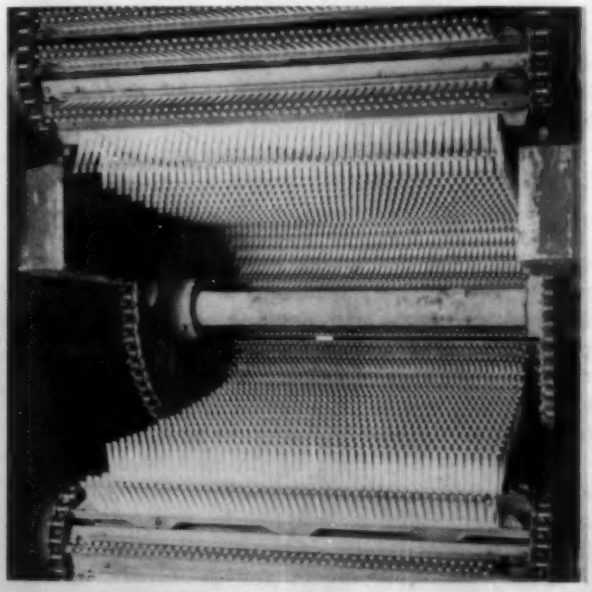
With the increase in speed, other steps took place all along the production line. Gradually the use of mechanical and pneumatic conveyors spread to the transporting of materials in process and of finished goods. Higher speeds also made necessary the development of automatic signals and controls to stop machines in case of defects in product or in case of jams, common to paper handling.

Hand in hand with this technical development went the development of quality of product. Chemical developments in matchbook manufacture kept pace with mechanical progress. Universal Match can be justly proud of its creation of a water resistant striking strip and its introduction of a unique process of controlled drying of match heads using lithium chloride as the desiccant.

Along with these advances, major efforts were applied to the improvement of printing processes and equipment. Universal Match developed its own dry-offset multicolor presses specially for printing small orders, requiring little set-up time and low cost plates. This development enabled the company to offer small-budget advertisers all the advantages of multicolor designs and imprinted individual messages including names, addresses and local advertising, on almost the same basis as afforded larger advertisers.



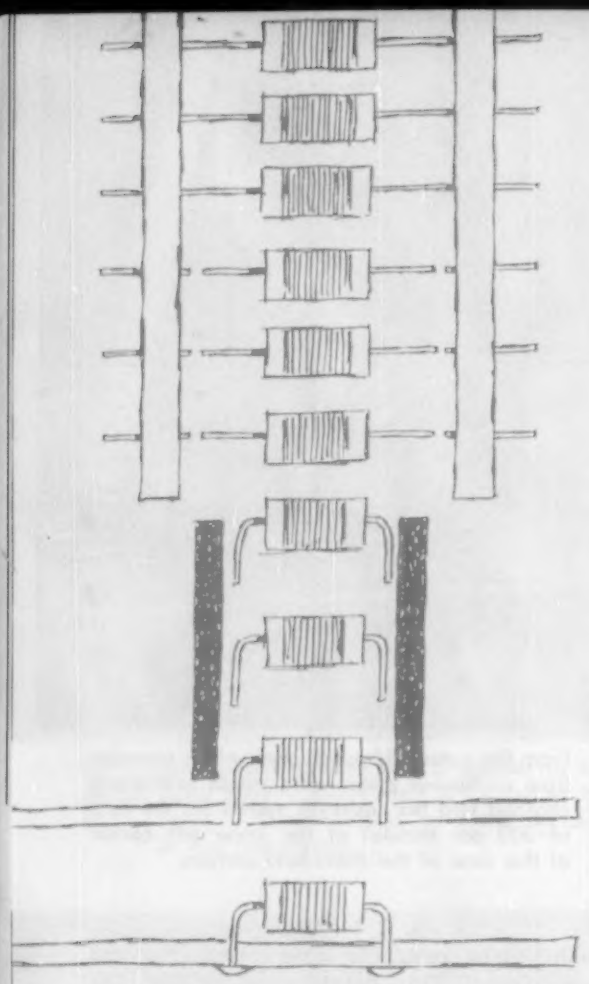
5 From the automatic punch press which operates from continuous paper rolls, match combs are charged into the conveyor system (at the rate of 300 per minute) at the lower left corner of this view of the chain-held carriers.



6 After the match combs are dipped in paraffin and heads applied they are carried into the drying chamber which is air-conditioned.

And so it is that the correlation of the development of high speed in automatic machinery is not foreign to the manufacture of matchbooks . . . in fact, it can be seen that matchbook manufacture contributed much to modern machine development.

7 Matchbook assembly machines operate at speeds in excess of 450 rpm. Cover stock is cut and folded around the matches, wire-stitched in place and books stacked in alternate directions ready for packing.



Those who insist that automation is primarily a matter of electronics should examine automation in the electronics industry. What do we find? Results of mechanical, electrical, industrial and even chemical engineering—far from any electronic monopoly. And automation is not applied just to be modern, but to produce in greater quantity with higher quality, more economically.

MODERN DEVELOPMENTS IN

AUTOMATION FOR ELECTRONICS

By WILBUR R. ELLIS
Associate Editor

RELATIONSHIPS between automation and electronics may be summarized by the phrase, "automation for electronics and electronics for automation." Relative knowledge of these two functions is dependent upon the position of the viewer—whether part of or outside of the electronics industry. Automation for electronics is the direct concern of the electronics manufacturer, electronics for automation has been of great interest to industry generally, although only the future will tell whether or not electronics will be the industrial panacea that is often predicted.

It is interesting to note the separation that has existed between the electronics industry on the one hand and industry generally on the other. Concentration by the electronics industry on its own automation problems has not been accompanied by interest in automation applications of electronics in other industrial applications. The "black box" has been furnished, but only as a component and with little effort toward an integrated approach. Many companies outside of the electronics industry have set up their own electronic groups or purchased electronic companies in order to provide themselves with this service.

Why, then, has the electronics industry been so intent upon developing automation for its own uses? The answer, common to many other industries, is consumer demand—demand by the public for radio and television equipment and by the government for defense equipment. Here is the booming market for electronic products; here is the way to meet it—with automation.

Seldom has any type of product been affected as radically as has electronics in the effort to apply automation techniques to production. At first glance, the circuit of ten years ago presented a most unsuitable object for automated manufacture—spaghetti wiring, delicate and varied components, hand soldered connections and difficult assembly sequences. However, pressure for volume production and decreased costs seem to sweep away the most stubborn obstacles. Starting with the possibilities presented in printed circuits by work in England and our own National Bureau of Standards, we have witnessed the conversion of an industry from "hand minded" to "automation minded."

Printed circuit boards have mushroomed to include several basically different methods to pro-

duce wiring boards automatically. Components have been redesigned to be adaptable to automatic assembly. Automatic soldering techniques have been developed along with terminal inserting systems. Circuits can now be wired from information stored on punched tape, and testing sequences are programmed on punched cards.

Automation has done much for electronics. But the lesson here is that automation is not a goal in itself. Automation is a means to more profitable operations and can be applied only as such. Success is measured in suitable and maintained profits, not in degree of automation. Automation for electronics is of interest to all industry because of the poignancy of this economic discipline, because of the gross effect that automation can provoke and because of the automation developments born in the electronics industry.

Fig. 1—First step in producing etched wiring boards at Admiral Corp. is photographing a large drawing of the wiring pattern to reduce it to a sharp, actual size negative. The negative is then placed in a printer as in the photographic process and the picture printed on a plastic sheet, one side of which is covered with a thin copper foil.

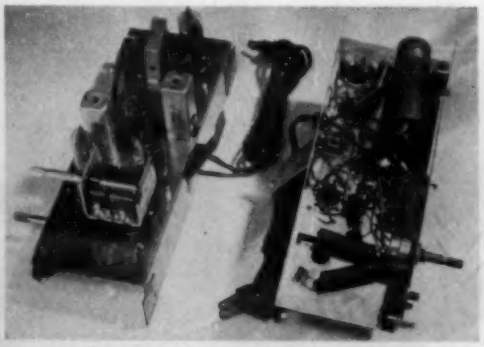
▸ Wiring Board Techniques

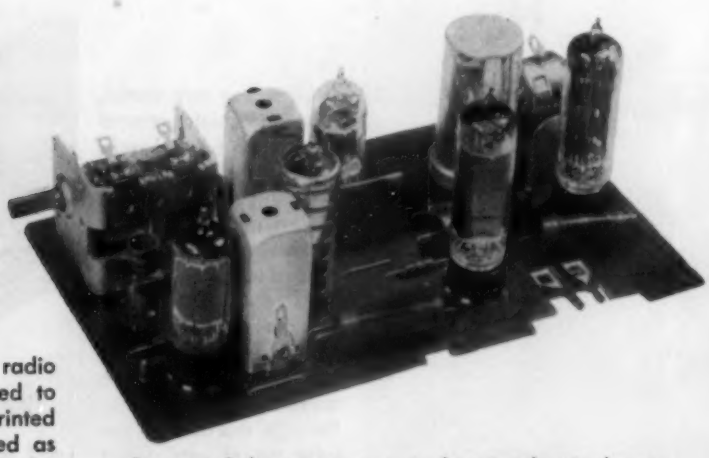
As has been mentioned, the real basis for breaking the automation barrier in electronics manufacture was development of the wiring board idea. These boards are generally called "printed circuits" although the printing method has been supplemented by several other processes, each of which produces a board either with an inherent or production advantage. Various types may be classified as etched wiring, embossed wiring, stamped wiring, pressed-powder wiring, painted wiring, and plated wiring.

In addition to the wiring function, a surprisingly large number of successful applications of the wiring board technique are in the switch and commutator category. Complex rotary and sliding switch configurations can be produced at a cost below that possible with other systems of manufacture. Binary code disks, for instance, are made most economically by wiring board methods.

Etched wiring may claim credit for naming the entire group "printed circuits" since many of the manufacturing techniques are borrowed from print-

AUTOMATION CASE HISTORY





Radio chassis of a Sylvania 5-tube ac/dc radio manufactured by automated methods compared to a similar conventionally wired model. A printed circuit panel with circuitry on one side is used as a base, and all components are inserted from the top side of the board. All solderable connections are made on the lower side. This chassis has the same number of electrical components except for wiring as the conventional steel chassis that it replaces and the two are equivalent in electrical performance. The chassis, as shown, is complete except for speaker and loop. System and equipment used to manufacture this product in an automated series of operations were designed and built by Sylvania.

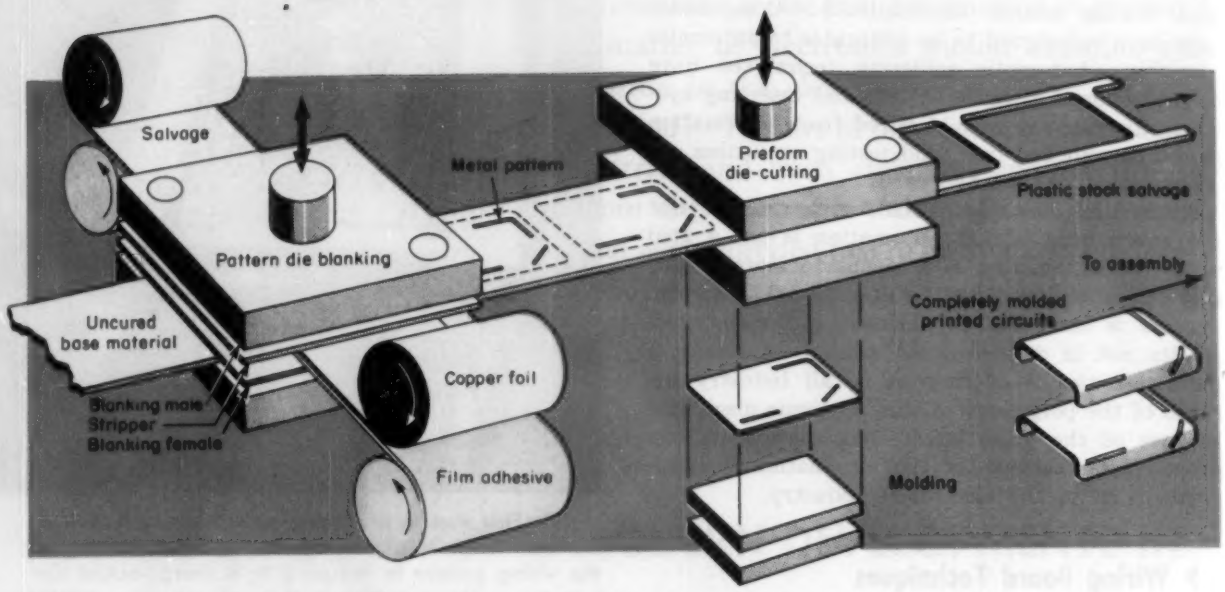
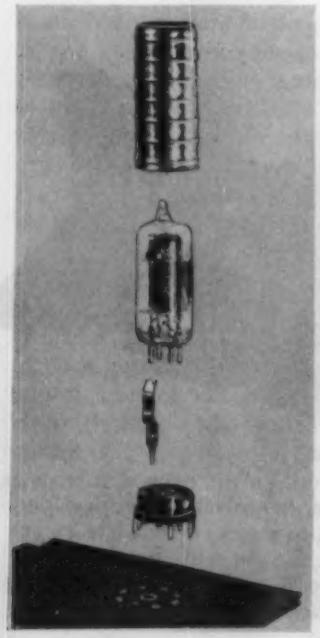


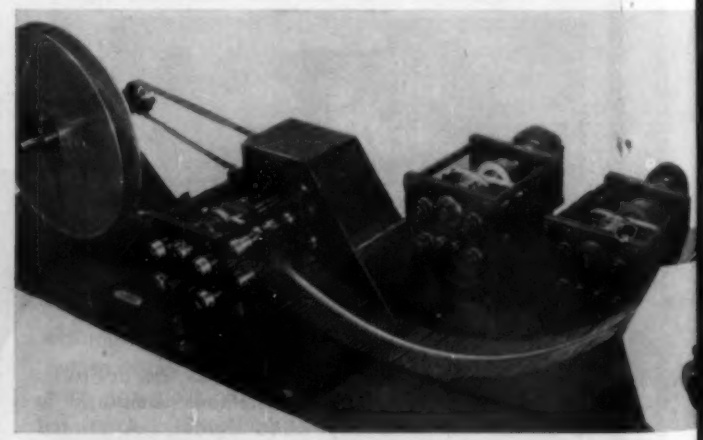
Fig. 2—Wiring boards can be produced from copper foil, adhesive and plastic base material using a punch press and plastic molding press. This system is a development of Automation Associates, New York.

ing arts and trades, *Fig.* 1. Herein lies an advantage of etched circuits — know-how has been developed insofar as the mechanics of production are concerned. An etch resist can be printed photographically using the materials and methods of the photoengraver. Screen printing or offset printing may be used to deposit an ink-type resist. Starting point is a master drawing which is photographed; the negative can be used in photoetching or indirectly to produce a screen stencil or a printing plate. This process can be performed in somewhat of a reverse method by applying the resist in the negative of the desired pattern, plating the exposed copper pattern with solder, removing the resist and etching with a chemical that does not attack solder. Resulting "tinned" pattern is an advantage in subsequent soldering operations and through plating of holes.

Advantages of the etch method are: Low investment cost, excellent pattern definition and



Tube socket with shield, tube and shield ground connection for Sylvania 5-tube radio. At the time this set was designed the only tube sockets available for printed circuit applications required a different socket for each tube. To permit the use of one common socket for all applications in this set, a new tube socket was developed.



Lead cutting machines at Sylvania take resistors mounted on tape and cut the leads to the desired length. A reel of resistors from the vendor is placed on one end of the machine; the end of the tape is then fed through the cutting unit and attached to the narrow aluminum reel. The resistors are cut at a rate of 2500 per minute.

reproducibility, wide variety of conductors and insulators, good bond between conductor pattern and insultor, possibility of plated-through connections, and existence of manufacturing methods and techniques. Disadvantages include: Limitation of insulators to low moisture absorbing materials, limitation of conductor-insulator combinations to those with good adhesive bond, and possibility of adverse effect of bonding adhesive on electrical properties.

Embossed wiring is a method in which the wiring pattern is pressed into a laminated board consisting of the insulator base and copper foil. After pressing, the unwanted portions of copper foil are removed by a mechanical operation leaving the recessed pattern imbedded in the insulator base.

Advantages of the embossing method are: Electrolyte does not come into contact with the insulator, and relatively cheap dies can be used to press the pattern. Disadvantages are: Lack of sharp definition of pattern, possible harmful effect of abrasive action on the insulating qualities of the board and hence the necessity of special insulating board material.

The *stamped wiring* technique is similar to the embossed method in that an embossing die is necessary. This die shears the copper foil in the circuit pattern after which the pattern is laminated to the insulating backing by application of heat and pressure, *Fig.* 2.

Stamped wiring process has the advantages that might be expected for any die stamping process such as speed, etc. A variety of metals and insulators is possible as is accurate registration because of the mechanical nature of the operation. The stamped circuit process does not contaminate the finished board with solution residue which might affect the characteristics of conductor or insulator. The main limitation is that the stamping die is expensive compared to setting up for etched circuit production. Also, time required to cure the adhesive is a limiting factor on the stamping speed.

Pressed powder wiring is a method in which a metallic slurry is applied to the insulating base,

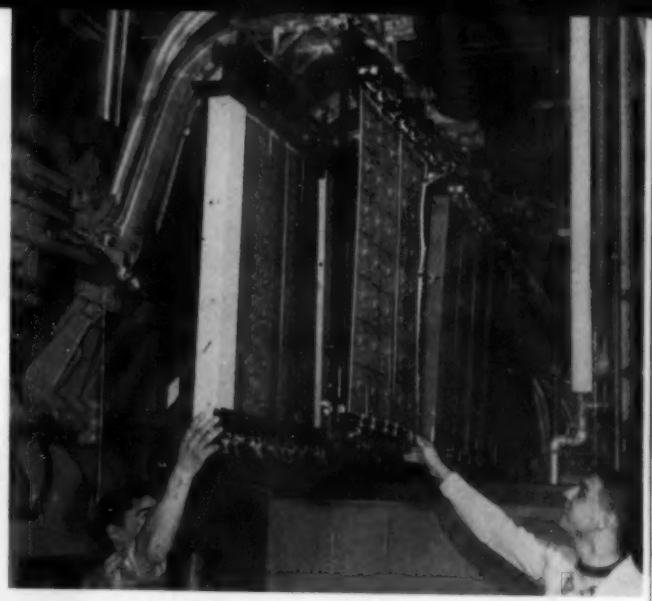
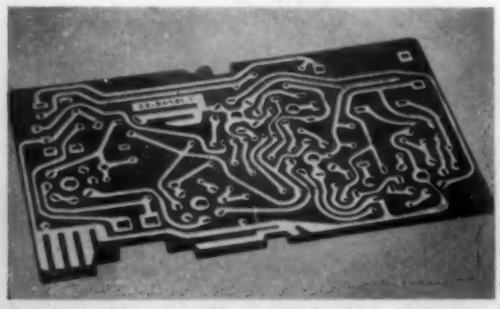
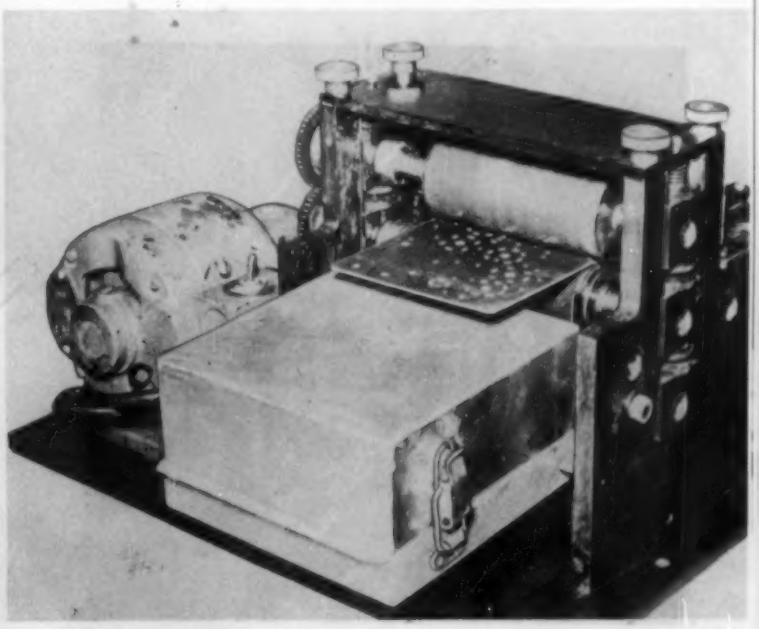


Fig. 3—General Electric facilities for production of wiring boards for electronic units in radio, TV sets and radar systems. In this 75-ft plating tank the copper wiring pattern is electrolytically deposited on plastic boards. After processing, the strips are cut into seven individual patterns. The line is expected to produce over 5-million individual boards for G.E. and its customers in 1956.





Fluxing machine is a simple roller coating unit which applies a rosin-base flux onto the wiring panels. One operator can flux 1000 boards per hour. The flux thickness can be controlled and the flux, being nonactivated, does not have to be removed after soldering. The machine is designed to accommodate variations in board size and leaves the edges of the panel clean for travel down the transfer line as rosin on extreme edges eventually causes sticking on the tracks.

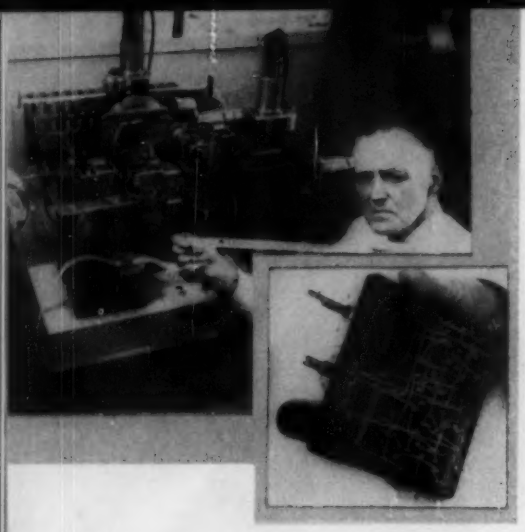


Fig. 4—Mechanized wiring and wrapped connection system developed by Bell Labs. Various terminals are wired together as programmed on punched paper tape. Connections are made by tightly wrapping wire around square terminals thus eliminating soldering.

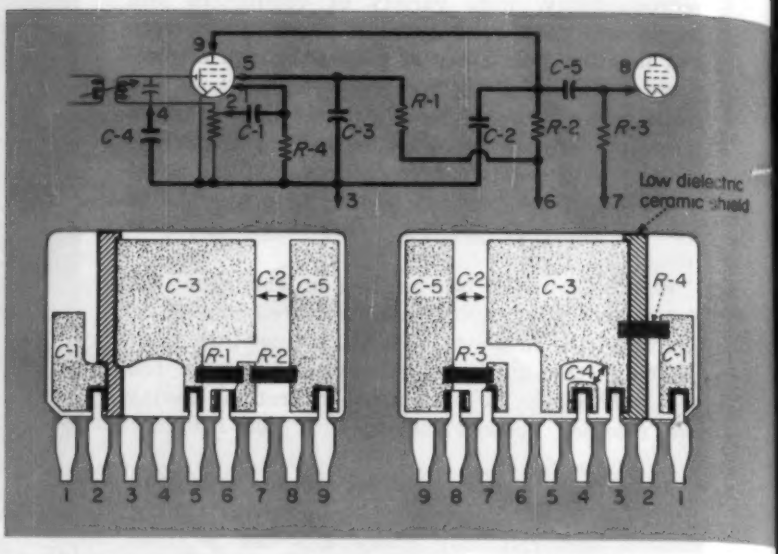
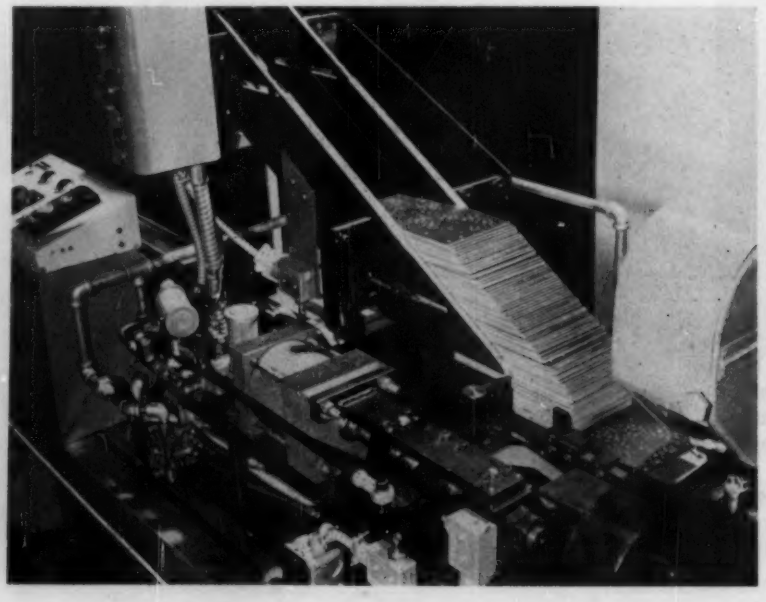


Fig. 5—Ceramic based coupler unit, product of Centralab, a division of Globe-Union Inc., Milwaukee, Wisc., for standard radio receiver. These components reduce the number of insertions necessary since they are circuit combinations of individual components. These are true circuit boards.

dried, then hot-die stamped to produce a conductor pattern on the insulating base. Providing of holes or notches in the base can be done either before or during the embossing process. Metal which has not been embossed by the hot die is removed by washing the panel in water.

Advantages of this technique are: Excellent bond strength under varied temperature conditions, no electrolytic contamination, elimination of bubbling and blistering on large conductor areas, accuracy and duplicability of patterns, low cost of embossing dies and simplicity of production cycle. Disadvantages are: High cost when using silver as conductor (most frequently used), and the possibility of silver migration which may take place under high dc potential and extreme humidity.

In the *painted wiring* technique, metalized paints or resistor paints can be used with the insulator base as interconnecting circuitry, resistors, ca-



Transfer machine automatically shifts printed circuit boards in sequence from station-to-station. The equipment is of the straight-line type and is made up of sections, each 4 feet long. Each section contains four stations at which component-insertion units may be located. Depending upon conditions, as many as three insertion machines may be located at one station. The first section of the assembly line includes the hopper feed for the printed circuit boards and the power supply and controls for the complete line.

pacitors and inductors. Ceramics are often used as base material. The paints are screen printed onto the base. This system is used in module type construction since a component circuit can be fabricated. This ability to form a circuit module—a circuit section of resistor and capacitor components—is the major advantage of this technique. The Tinkertoy module is constructed of a ceramic, paint-printed unit.

A *plated wiring board* is one produced by depositing a conductive pattern on an insulating material by electroplating or reduction plating, *Fig.* 3. The resist is screen printed over the area not to be plated, the plate applied and the resist washed off.

Advantages include good pattern definition and reproducibility, electrolytic deposition without pin holes, possibility of plated-through holes without an extra operation, flexibility in pattern thickness, and reduced cleaning cost. Disadvantages are relatively poor thermal bond and possible detrimental effects of electrolyte on the insulating material.

As a general comment on wiring boards produced by the means discussed, conductivity depends upon the material used as conductor and the manner in which the material is formed into the wiring pattern. Bond between wiring pattern and insulating base depends upon combinations of material for each and the method of fixing. Insulating qualities of the base may be affected by adhesives, heat and pressure, plating solutions, etchants, stamping dies and abrasives. Subsequent operations after the wiring board is formed also must be considered when selecting materials and method. Such operations include drilling, punch-

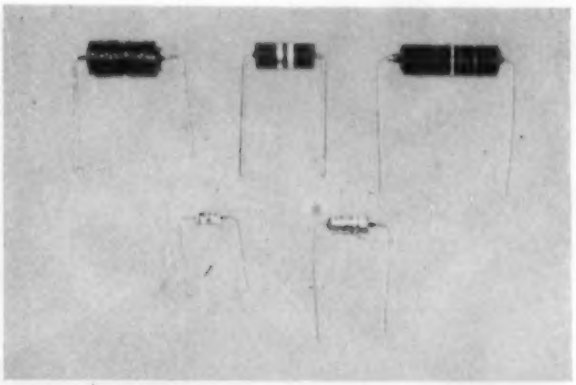


Fig. 6—Axial lead components, most suitable type for machine assembly. These components, used by RCA, should be handled by the leads and can be either magazine or belt fed.

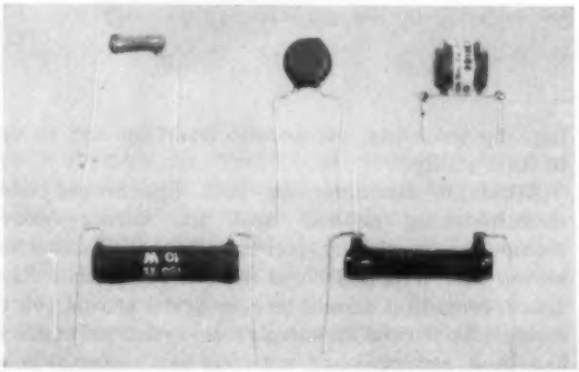
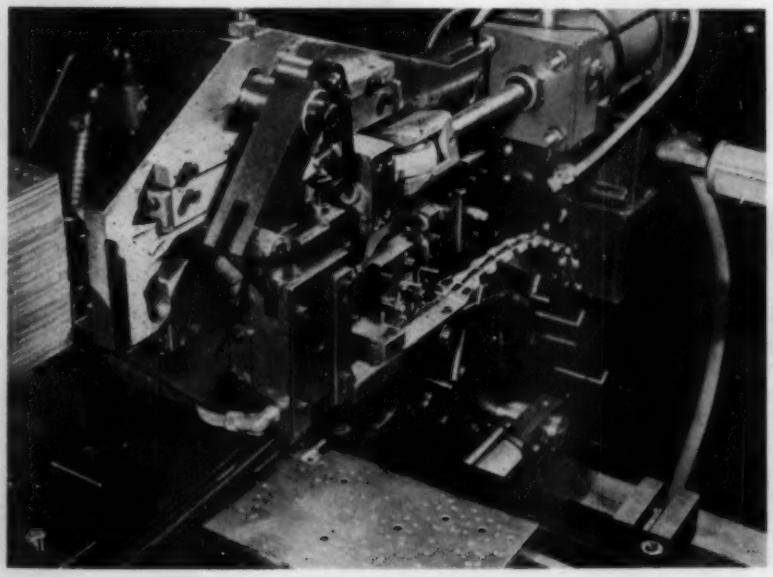


Fig. 7—Radial lead RCA components are more difficult to handle because of orientation problems and lead spacing. An extra bend is often required to allow lead grippers to clear the body of the component.



Insertion machine automatically feeds, cuts, inserts, and clinches to a circuit panel a pair of terminals used for the 117-volt interlock connection. The interlock terminals are fed to the machine from a reel containing 2000 pairs of terminals.

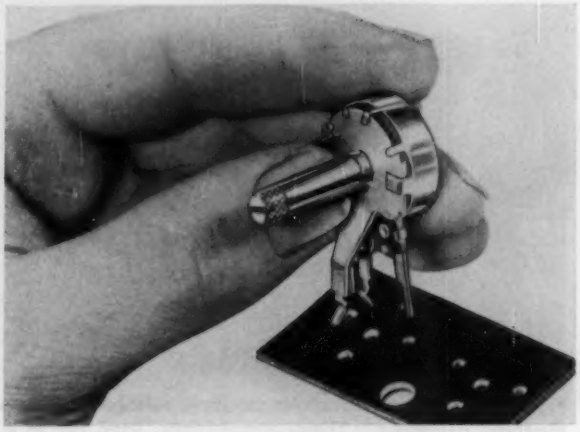


Fig. 8—Snap-in variable resistor manufactured by Electric Component Div. of Stackpole Carbon Co., St. Marys, Pa. Legs snap into the board to form supports and electrical connections. Terminals are tin-lead coated for soldering by the dip soldering method.

ing, dip soldering, component insertion and so on to final utility.

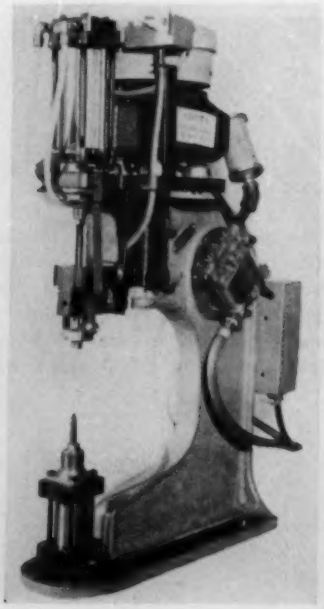
Although dissimilar in both appearance and manufacturing method from the wiring board techniques previously mentioned, the *mechanized wiring* and wrapped connection development, *Fig.* 4, is a form that should be considered at this point. Automatic wiring of complex electrical assemblies has been accomplished with an experimental machine developed by Bell Labs. Instructions are fed to the machine from a punched tape and wire is fed from a large spool to one of two rotating spindles. The wire is pulled in an inverted *L* shape movement to a connecting terminal and at the same time the wire is cut to correct length at the second spindle. Insulation is removed from the ends of the wire as the spindles wrap it around the connecting terminals. After one connection is completed, the spindles pick up more wire and move to the next two terminals according to punched tape instructions. A limitation of this system is the expansion of the wrapped wire under high-temperature conditions.

In order for components to be assembled onto wiring boards to form completed circuit boards, holes must be drilled or punched into the boards. Large runs are suitable for one-shot presses whereas short-run jobs are done with template-guided presses or drills. RCA has developed a punched paper tape controlled press.

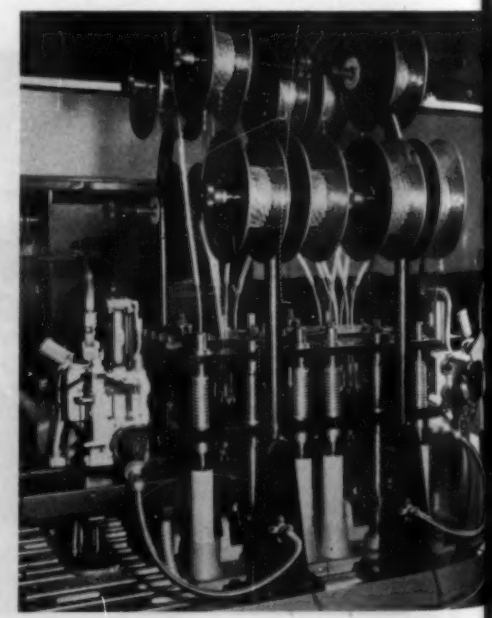
Components for Automatic Production

Before examining the mechanical characteristics of electronic components for automatic assembly, it is appropriate to elaborate on production of components by the ceramic based pressed powder method discussed earlier. These elements are widely used to produce resistor-capacitor networks for television and radio use because of uniformity, economy, and reduction in wiring costs.

Many design techniques are used to enable a portion of a circuit with components to be compacted onto a small plate without loss in performance. In final form these plates may be provided with tab leads for plug-in assembly to another circuit board, *Fig.* 5. Capacitors on ceramic base circuits behave in the same manner as com-



Pin inserter takes a standard terminal pin and automatically feeds, inserts, and clinches the pin to the board. The pins are dumped into a small vibratory hopper where they are oriented and fed to the inserting mechanism. The bowl capacity for this machine is approximately 2500 pins.



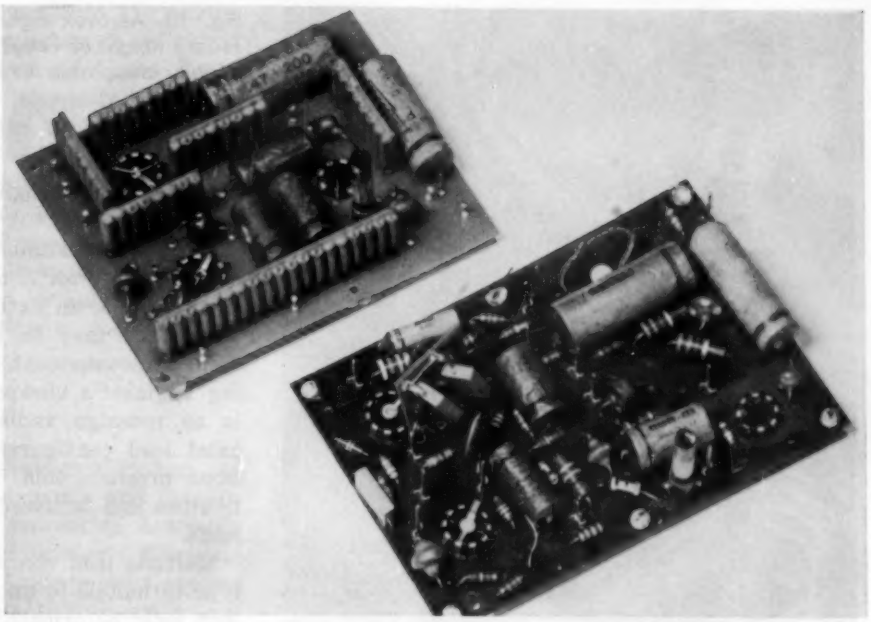


Fig. 9—Packaged assemblies forming circuits within circuits reduce the number of individual insertions necessary as illustrated by comparison of two boards. The upper board contains Erie Resistor Corp. packaged assembly circuits. Number of component insertions has been reduced from 44 to 16.

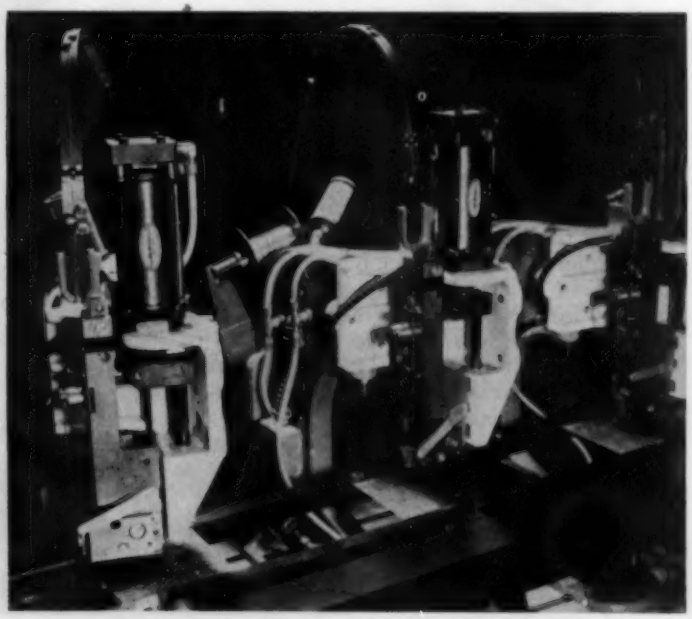
mercial types of individual ceramic capacitors. Resistors on these circuit plates are painted carbon composition.

Development of electronic components for automation has followed a two-step sequence: First, development of components designed for wiring boards; and second, development of components designed to be inserted automatically into wiring boards.

Axial lead components of cylindrical shape, *Fig.* 6, have proved to be the least difficult to handle of the present component configurations. If it were possible to redesign all nonpolar two-lead components into the axial form of the resistor, automation would be greatly aided. Many components have been redesigned into this form. Excessive lead-wire length, kinks and bends, and other wire variations are the only difficulties experienced with axial lead components when handled properly.

Handling of axial components has taken several different paths, each emphasizing a particular advantage. These methods of handling are best described by the packaging form—how the components

Multiple terminal inserter, feeding from reels, cuts and inserts terminals into the circuit panels. These terminals do not require clinching as they are designed to wedge lock in the holes provided. Each machine has a capacity of up to eight terminals. These machines are permanently positioned on the line, and the location of a terminal at a desired point is caused by a pair of plates which are changeable. New plates are made for each new circuit layout. Multiple machines are used on TV applications where as many as 13 or more terminals are used in one board.



Jumper insertion head takes tinned copper wire from a reel, cuts, forms, inserts and clinches a jumper into a circuit panel. The wire reel capacity is 25,000 jumpers. These machines, as the others, are air powered and allow flexibility in component placement on the circuit panel.

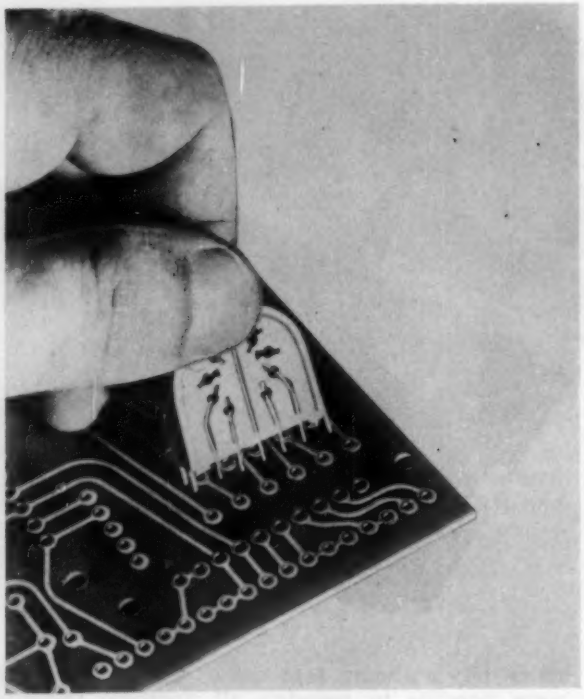


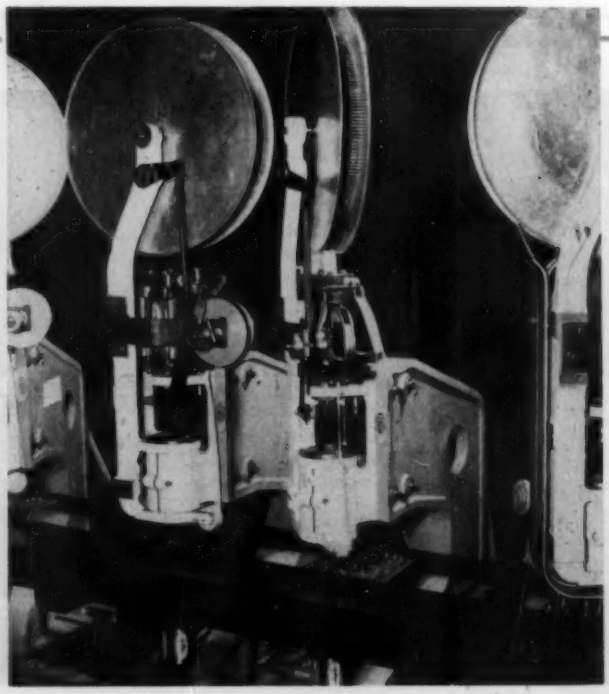
Fig. 10—Aerovox right angle tube socket is used to reduce height of circuit board assemblies. Sockets are equally adaptable to hand or machine insertion.

are fed continuously into an assembly operation. The two most popular systems are, (1) components fixed to pressure sensitive tape and, (2) components delivered in containers which are used as magazines when attached to the assembly machine. Advantage of the tape method is that the component is positively handled—always fixed to the tape. Advantage of the magazine container is elimination of the tape cost which can be considerable when high-volume products are being assembled.

Since lead positions vary so widely in radial lead components, *Fig.* 7, machine insertion is more difficult. Also, an extra bend is often necessary so that leads may be handled without interference from the component body. From the manufacturing engineer's viewpoint the only logical solution is to redesign radial lead components into the axial lead configuration. When other considerations preclude this, many of the radial lead difficulties can be overcome by the use of short stiff leads.

Multiple lead components are the most difficult type to handle in automated systems because each lead must be oriented with respect to its hole and all the leads must be capable of simultaneous insertion. For hand insertion these components carry stamped markings or color codes for indications of orientation, but a machine must be given some way to sense the position of the component fed to it. Unsymmetrical leads and flatted corners are the most obvious ways of doing this.

Components of this class may have terminals with round wires, flat tabs or in a circular pin configuration. Leads may be either preformed or designed to be formed after insertion in the wiring board. Preformed type includes volume controls, *Fig.* 8, electrolytic capacitors and some transformers. Single components may be packaged or



Resistor insertion machine automatically forms, inserts and clinches resistors to the circuit panel. This machine uses precut resistors, body mounted on tape and wound into 12-inch diameter reels ranging in capacity from 1000 to 2500 resistors, depending on size. The reels are mounted at the top of the machine, and resistors are fed down through a track into the actuating mechanism. Tape carries the resistors through the machine and feeds them through a take-up mechanism. The machine is air powered and requires only two connections to be made operative.

grouped, *Fig.* 9, before insertion into the wiring board in order to reduce the number of individual insertions and simplify the wiring board itself. Some components for circuit boards fall into the adapter category such as tube sockets, *Fig.* 10. Then, circuit boards themselves must be plugged into larger circuits so that connectors for entire boards have been developed, *Fig.* 11.

Automated assembly can be simplified considerably by standardization of hole spacing. Definite grid arrangements have been established which, of course, mean standardization of lead spacing.

▸ Automated Assembly

Electronic circuit boards—conglomerations of wiring boards, components, supports and connections—require methods for automatic assembly that are common in many industries. Elements must be prepared or inspected prior to the assembly operation; fed and oriented in the assembly machine; held, assembled and fixed into the base or body of the assembly; and then the base must be moved from station to station to receive additional components. The electronic industry boasts a number of systems that perform these operations.

Major differences in these systems are the method of handling the components and the method of handling the boards. As was noted when discussing components, handling of these items is accomplished either in belt form or magazine load. Boards are transferred either on slides or fixed in pallets.

The central argument between taping and magazine loading seems to be one of costs against ease of handling. The proponent of the magazine points out that few component manufacturers are interested in tape packaging and that considerable quantities of tape are consumed—in one instance ten miles per week per line feeding 20 components at a tape cost of about $15,000 per year. However, if such costs are accepted, gravity will not be the necessary means to feed light weight objects such as diodes, resistors and capacitors. Static electricity, oil, dirt, wax, air currents, and vibration all are hindrances to reliable feeding and these factors move some assembly-machine de-

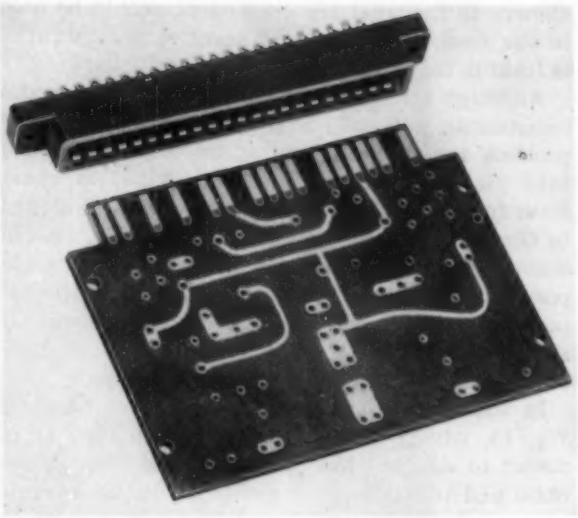
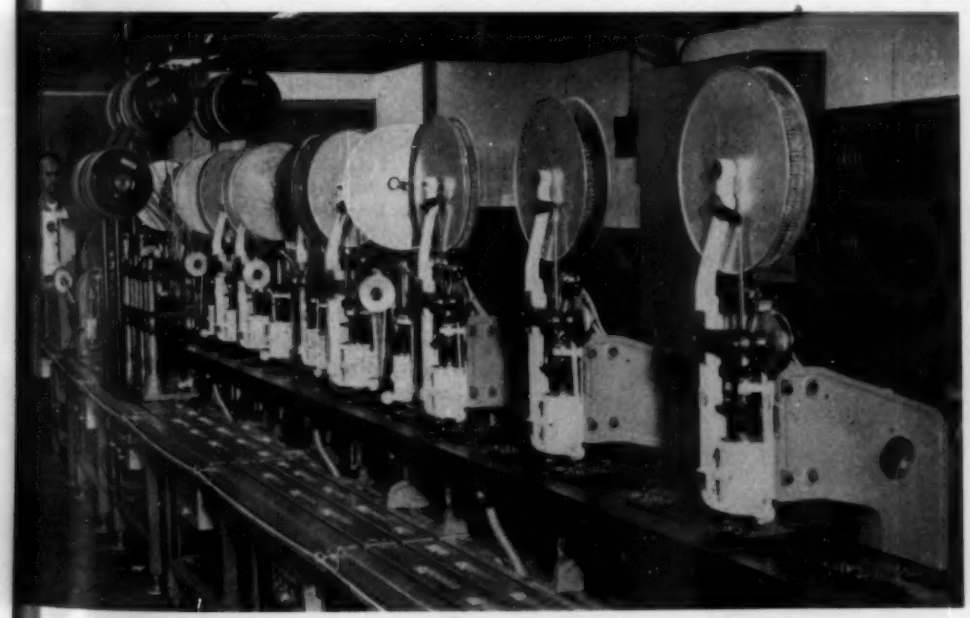


Fig. 11—Circuit board connector of DeJur-Amsco Corp. with 22 contacts used for quick insertion and removal of the entire board.



General view of the Sylvania assembly equipment. During the initial production run of this radio model, 19 components were inserted automatically and the remainder inserted by hand. The machine-inserted parts included the two interlock terminals, three connecting pins, four jumper wires, seven resistors and three tubular capacitors. After all the parts, including tubes, had been assembled, the chassis were automatically and selectively soldered.

signers to feel that the component should be held in the feeding package and never released until it is fixed in the wiring board.

Although terminals may be considered as axial components, insertion into the board is a special problem because so many of the same insertions take place. Terminals are usually fed in chain form from reels and a number of terminals staked to the board by one stroke of a press, *Fig.* 12. In some systems a separate reel feeds each terminal position, in others a single reel feeds all terminal positions. A critical requirement of any terminal assembly operation is ease and speed of change-over to another board pattern.

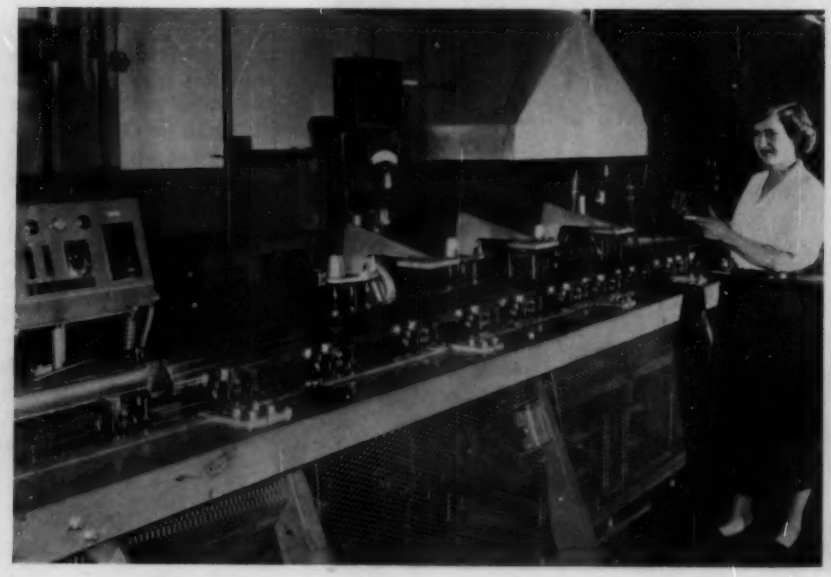
In addition to a variety of components handled, *Fig.* 13, wiring board dimensions also vary from circuit to circuit. Few manufacturers even in the radio and television field are in a position to utilize some 8000 identical circuits per 8-hour shift so that assembly systems must not only be designed to accommodate a variety of boards but the change-over from one board to another must be simple and rapid.

Factors favoring a conveyor for boards without pallets, *Fig.* 14, include cost of pallets, tolerance accumulation with pallets, necessity of recycling of empty pallets and automatic feeding of nonpalletized boards, *Fig.* 15. Most boards are rectangular with the reference surface at the board edge, so that it appears logical to index to this edge on the conveyor. The obvious advantage of the pallet conveyor, *Fig.* 16, is the great versatility in board shapes that can be quickly and easily accommodated. In some cases pallet-held boards present a larger clear area for insertion of components than do nonpalletized boards.

With so much emphasis on adaptability to short run requirements it might be expected that punched card or tape controlled assembly systems would be developed. One such system, *Fig.* 17, produces wafer type boards suitable for stacking and is punched-card programmed. In one cycle the system selects one component from up to 24 different types and transfers it to the insertion station; transfers a wafer to the insertion station and positions it to receive the first component; forms the component leads by bending them to coincide with holes in the wafer; inserts the component leads through the wafer; mechanically fastens the component to the wafer by stapling the leads; solders the leads to the wafer; and then positions the wafer to receive additional components.

In most automated assembly systems components are electrically connected to the wiring board by the dip-soldering method. This process is a critical part of the overall assembly system. One of the most important and difficult control problems is with the solder itself. Impurities, particularly zinc, build up rapidly in the solder pot and can affect the electrical and mechanical properties of the joint and also solder across closely spaced conductors that are not meant to be shorted. Wire size is also a function of joint strength—as wire circumference increases, soldered-joint strength increases.

Preparation before dip soldering can include application of flux and pretinning, or plating the conductors to be joined. Plating is objectionably expensive so that most emphasis has been placed on development of noncontaminating fluxes. For successful dip soldering it is essential that the solder "wet" the component leads as well as the board



Soldering machine automatically transfers and selectively solders completed radio chassis assemblies. This machine pumps liquid solder through tubes located at specified positions which match the connections to be soldered on the chassis. Liquid solder maintained at 470F is continually pumped through the tubes. As a chassis is positioned in a soldering station, the soldering unit is raised so as to allow the solder to contact the terminals and circuitry on the board.

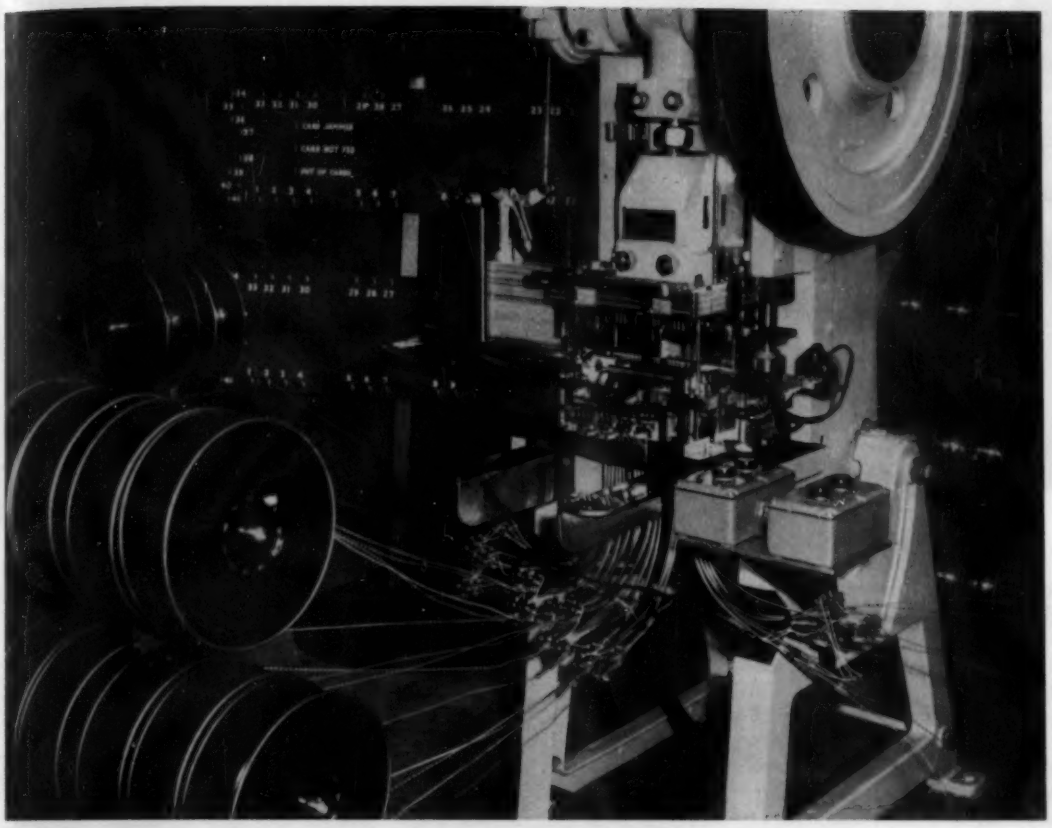


Fig. 12—Berg Mfg. Corp. machine which stakes tin-plated brass terminals to wiring boards. With each stroke of the press, as many as 41 terminals are staked to a board.

conductors. Consequently it is desirable to have these leads tinned with a eutectic solder and then coated with stearic acid (flux). Leads so treated have dip soldered satisfactorily even after two years of storage. Dip-soldered joints that are 100 per cent reliable have not been attained however, so that efforts have been directed to wrapped wire connections and individually soldered connections mentioned previously.

Automatic Testing

Of considerable importance in automating the production of electronics is the need for equipment to test the product. Truly automatic operations can be realized only by applying techniques of design, manufacture and quality control to the product in co-ordination with each other.

It should be pointed out that emphasis is on the production of parts which perform satisfactorily. Inspection is performed not merely to sort the good units from defective ones but to increase the output of good units. An efficient inspection system must include methods by which parts are made correctly the first time. This of course might be called feedback but this feedback is in an organizational sense rather than a physical sense.

Automatic testing of circuit boards, *Fig.* 18, can be resolved into two general areas—electrical inspection and electrical evaluation. Electrical inspection is the process of assuring that the assembly has the proper connections and that its

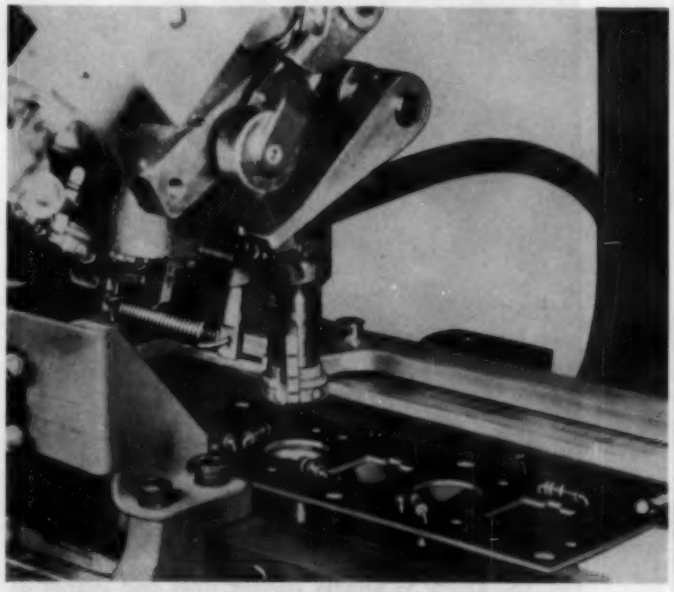


Fig. 13—Button or wafer type tube socket automatically inserted into a board at one station of United Shoe Machinery Corp. assembly system.

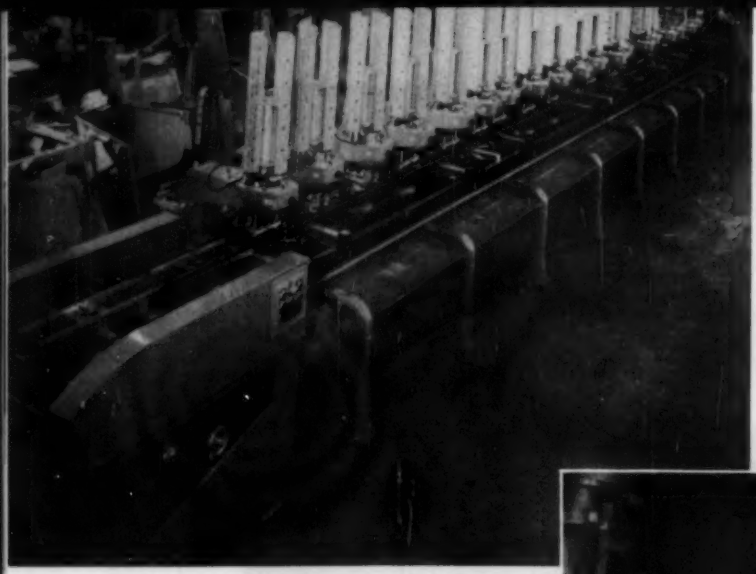


Fig. 14—Latest version of General Mills Autofab automatic assembly machine will deliver 12 assemblies per minute including normal downtime due to faulty components. This is a magazine fed system.

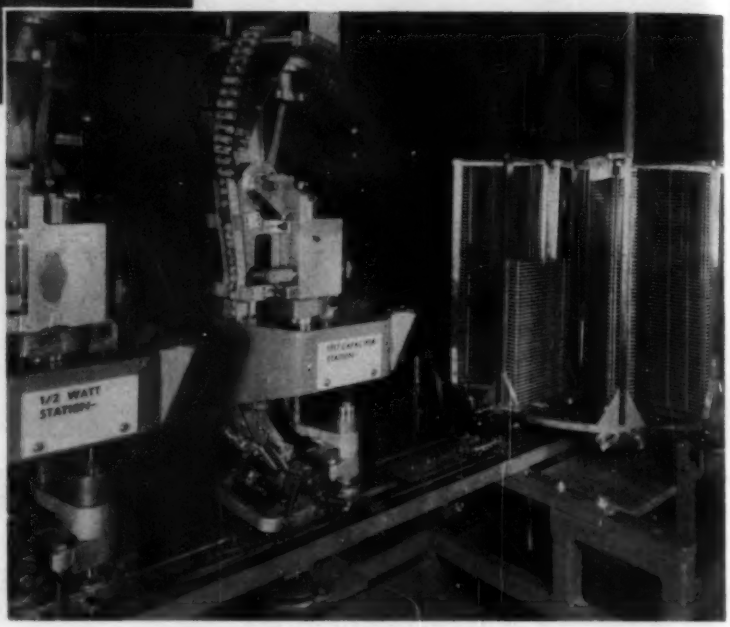


Fig. 15—Autofab automatic assembly line in use at IBM's Kingston, N. Y., Military Products Division plant. Printed circuit cards feed down onto the conveyor from the turret at the right. As they move down the line, each stops in turn under each of 24 attaching heads (the first two of which can be seen on the left) to receive assorted electronic components from a tape feed. The circuit card turret and component tapes feed automatically as the conveyor moves and, when emptied, are refilled while the machine remains in operation.

Fig. 16—Ability to handle varying sizes and shapes of boards without sacrificing accuracy of board location is primary advantage of United Shoe Machinery Corp. pallet system. Components are shown being tape fed.

components are within prescribed tolerances. Electrical evaluation is the determination of compliance with design specifications by measuring, recording, and analyzing static and dynamic circuit operation.

For both electrical inspection and electrical evaluation the basic operations of the equipment consist of five phases — programming, operational, measurement, comparison, and read-out. Programming sections perform the sequencing and can be done by a relay bank or tape or card devices. The operational system provides selection and control operations on the circuit board assembly and the test equipment components. Functions of the measurement, comparison and read-out sections are self-explanatory.

Automatic testing operations can add several benefits to the automated production of electronics such as decreased manufacturing costs, improved quality and quality control, increased production capacity, decreased investment, and decreased maintenance. Seldom can all these benefits be realized simultaneously but they provide an approach that can assure a thorough evaluation of

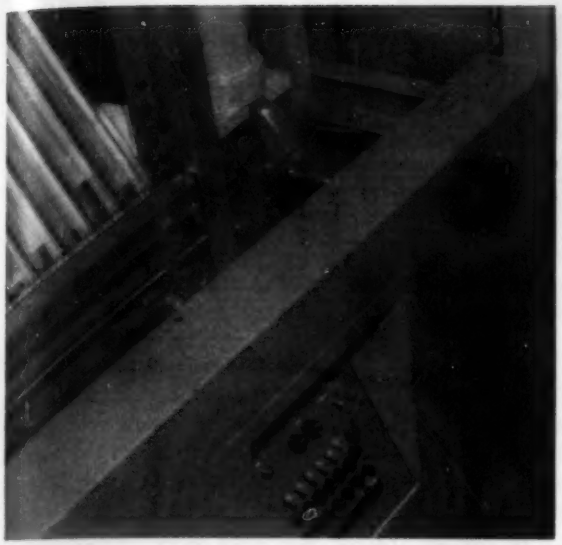


Fig. 17—Wafer type board produced by the Melpar MINI-MECH system with punched card programming. This system includes soldering in addition to assembly — each joint is soldered individually and automatically.

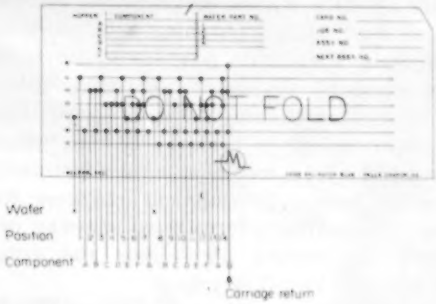


Fig. 18—Automatic test for circuits in subassemblies is run by this Supertester unit developed by Color Television Inc., San Carlos, Calif., and adapted to production requirements by General Electric's Light Military Electronic Equipment Department. It checks for continuity, leakage, voltage, impedance, resistance, and gain or phase relationship on more than 100 types of boards produced in the plant. The unit makes three tests per second, and tests the most complex board produced in the plant in 72 seconds. The completed subassembly is placed in a jig to make necessary electrical contacts. Test results are printed on tape inside printer, at left of jig.

the potential of automatic testing. An analysis of these benefits is usually a very convincing argument toward institution of this phase of automation.

▸ The Industry Automated

We might call the electronics industry a classic example of the application of automation in all its phases from redesign of the product for automation (wiring board and components), to automated manufacture, automated assembly, and automatic inspection. Of course this is not meant to imply that the electronics industry represents the ultimate in automation or is even in the forefront, but that this industry has been affected by automation in all its phases as much or more than other industries. Once again, it should be emphasized that economics determines the degree and extent of automation. It is a simple matter to point out where automation has not been applied but not so simple a matter to apply it at this particular point economically.

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ELECTROPNEUMATIC ELEMENTS UPGRADE CUTOFF OPERATION

A PRODUCTION RATE INCREASE of over 100 per cent while tightening tolerances by 50 per cent was made possible by applying an electropneumatic system to existing cutoff equipment at Shafer Bearing, Div. of Chain Belt Co. This improvement is typical of those which can be developed by an employee of the company. In this case it was a development engineer for Shafer who applied five Electro-Snap one-way impulse switches to control air valves and automatically cycle the cutoff machine.

Object of the operation is to cut roller blanks from bar stock. The original production procedure involved controlling a Radiac cutoff machine manually. The operator controlled the feed of the stock by a foot lever and brought the cutoff wheel down by hand. This method produced about 20,000 pieces in 8 hours. A major disadvantage of the manual method was the tiring of the operator which in turn resulted in a wide range in the lengths of the parts produced. This is true since the speed at which the wheel is passed through the stock is a prime factor in determining the precise length of the blank. Due to operator fatigue this varied considerably toward the end of the shift. Erratic manual control also caused high maintenance costs, and excessive downtime limited production.

Automation of the operation was achieved by use of air cylinders controlled through valves triggered by electrical impulse switches. The switches transmit an electrical pulse to start the cycle of the air valves and then drop completely out of the circuit. The operation now only requires the operator to load the bar stock on the feeder carriage, check accuracy of parts cut, and make minor adjustments and compensation for wheel wear—which can be done with the machine in operation.

Increased efficiency of the operation makes possible the cutting of 40,000 pieces in 8 hours. Uniform cutting action has permitted the tightening of tolerances from plus or minus 0.003 inch to plus or minus 0.0015 inch. By preventing stock movement while the wheel is in cutting position, interlocked controls have prevented wheel breakage from that cause, and the machine has cut off millions of pieces of stock in 10 months of daily operation without losing one day of service. From the operator's standpoint, fatigue has been nearly eliminated while accuracy and volume have improved.

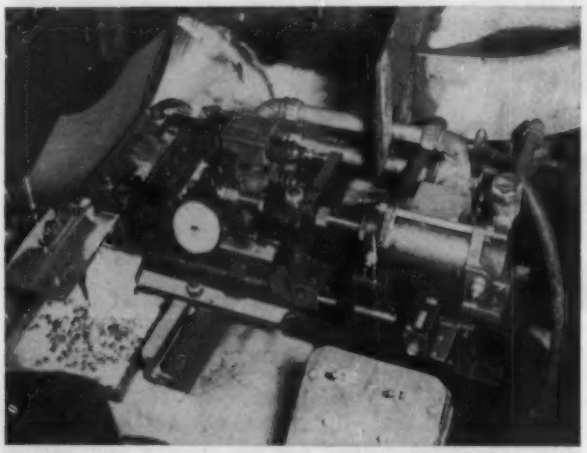

Fig. 1—Adaptation of an existing cutoff machine to automatic operation was accomplished by use of power cylinders controlled by electrical impulse switches.

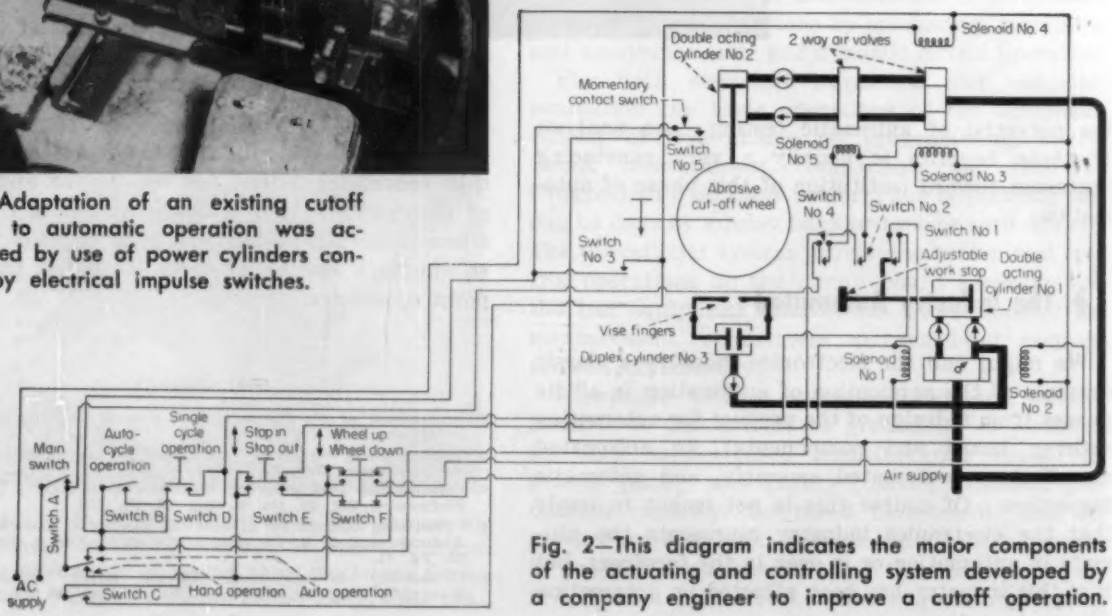

Fig. 2—This diagram indicates the major components of the actuating and controlling system developed by a company engineer to improve a cutoff operation.

Fig. 1—Four overhead trunk line conveyors carry cases from accumulator conveyors into the warehouse. The fifth trunk conveyor, coming from the vinegar building, parallels the other four to the palletizing machines, joining with one of them near the pallet loaders.

WAREHOUSING SYSTEM UNIFIED

TO IMPROVE HANDLING EFFICIENCY

Warehousing includes more considerations than storage alone. Here is a case history in which a company abandoned scattered facilities in order to capitalize on the possibilities of a single automated system.

ADVANTAGES offered by the latest developments in materials handling automation are major factors in planning a new warehouse installation. Operation of such a system often is similar in some respects to switch tower control of railroad trains entering large passenger stations. In fact, the operation may involve making up trains of predetermined and variable numbers of filled cases, routing and controlling their movements on accumulator and trunk conveyors, through pallet loading machines, and over subsequent conveyors and vertical lifts to various floors in the warehouse for storage or shipment.

A system of automatically controlled conveyors and palletizing machines for a new warehouse at the Pittsburgh plant of H. J. Heinz Co. incorporates fully mechanized warehousing operations from the case-sealing machines in nearby buildings to the shipping docks of the warehouse. Completion of the warehouse and handling system has centralized operations that had previously grown until storage facilities included six buildings in different locations in the Pittsburgh area.

The new handling system can receive as many as 48,000 cases of Heinz products from production lines during an 8-hour shift, and deliver them on pallets to conveyor terminals at any of 12 points on the three floors of the warehouse. Loaded pallets are moved by fork truck from these points to tiered storage or shipping docks.

Normal operation of the system requires the attention of two men for the conveyor and pallet loading machine operation and 33 fork truck operators. One operator controls the conveyors and pallet loaders and a second man with a motorized hand truck keeps the pallet loaders supplied with empty pallets and serves as a roving trouble-shooter. Fork truck operations include three movements

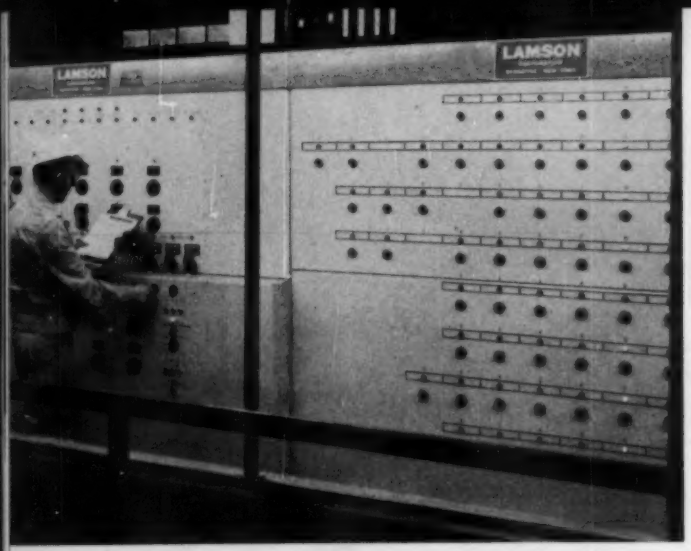

Fig. 2—Switching control center for the accumulator conveyors located near junctions with trunk conveyors. Panel controls include electrical plug-in cable connections for each trunk conveyor with selected accumulator conveyors, and multiple-contact dial switches to determine the number of cases to be discharged at one time from accumulator to trunk conveyor. These controls may remain fixed for extended periods of time. Indicator lamps on the panel also show operating conditions of the entire conveyor system. A three-station intercommunication system connects the control station, operator's pulpit in the warehouse, and the foreman of operations.

of pallet loads—conveyor to storage, storage to shipping docks, and conveyor to shipping docks. For maintenance of the system two electricians and two mechanics are available.

Packaging to Shipping

Conveyors from case sealing machines in buildings other than the warehouse carry the cases to feeder and accumulator conveyors. Twelve accumulator conveyors automatically discharge the cased products in predetermined numbers of cases onto any of four trunk line conveyors, *Fig.* 1, in the sequence in which these numbers of cases accumulate, *Fig.* 2. When a predetermined length of conveyor has been filled, the last case rests on a time-delay switch long enough to close a signal circuit so that a metering belt drive will be energized. As soon as the trunk conveyor onto which this accumulator discharges is cleared of cases from any other accumulator, the metering belt is started and the cases pass a photoelectric cell and are carried onto a deflector belt that passes over the four trunk conveyors. A manually positioned deflector pushes each case onto a selected trunk conveyor belt running at right angles to the deflector belt. As soon as enough cases to fill a pallet pass the photocell, the metering belt stops.

Conveyors operate at different speeds. The accumulators move at the rate of 65 f.p.m., the metering belts at 50 f.p.m., the deflector belts at 150 f.p.m. (spacing the cases and giving them adequate momentum to pass the deflector), and the trunk conveyors at 100 f.p.m. In the event of a jam on the accumulator which would close the circuits calling for energizing the metering belt, those cases that are free to move onto the trunk would be moved but no other accumulator could feed onto the trunk conveyor until the trouble had been cleared and the full number of cases to load a pallet had passed the photocell.

As each succeeding train of cases is ready to move into a pallet loading machine from a trunk

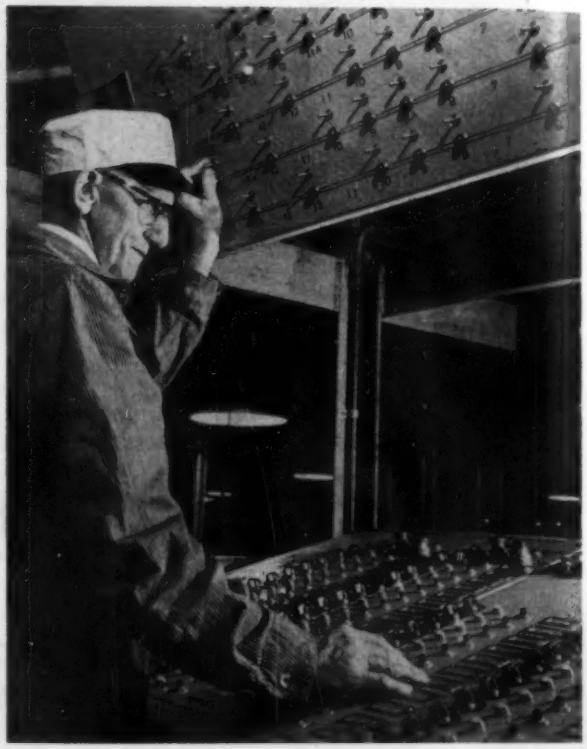

Fig. 3—Operator in the control pulpit identifies the product and selects the proper pallet loading pattern by pushing a button corresponding to the size of the case for this product. Pallet loads vary from as many as 210 cases to as few as 24 cases per pallet and weigh from 500 to 2900 pounds.

conveyor, a signal lamp is lighted in the operator's control pulpit, *Fig.* 3. He identifies the product and selects the proper pallet loading pattern by pushing a button corresponding to the size of case for this product. This also permits the cases to move into the pallet loading machine. Cases move into the machine at the rate of about 25 per minute and a photoelectric counter stops loading operations when the required number of cases has passed.

Although the four pallet loading machines are identical, they are set to handle a limited range of overlapping sizes. The pushbutton selects one of several relay control units or cartridges on each machine which automatically provides for the sequence of operations that will load the pallet in the desired pattern for a given size and shape of

case, *Fig.* 4. A three-position switch determines the floor level destination of the loaded pallet after it leaves the machine. It is turned only when a change in destination is required.

After a loaded pallet is ejected from the machine a short conveyor takes it to a vertical lift from which it is ejected automatically on reaching the preset floor level onto a terminal conveyor to be further handled by fork trucks, *Fig.* 5. If the pallet load is to remain on the third floor where pallet loading machines are located, it moves automatically through the vertical lift shaft onto a terminal conveyor on the same floor. There is a separate lift for each palletizing machine.

System Considerations

Provisions against improper operation of the integrated sections of the conveyors and palletizing machines are in evidence. Limit switches notify the operator of each case sealer when an accumulator conveyor cannot take any more cases. When a trunk conveyor is filled, limit switches also prevent movement of the feeding conveyors and signal the operator. If a palletizing machine should break down, there is a bypass conveyor to bring cases to floor level where pallets can be loaded manually. The palletizers are automatically stopped when an outgoing conveyor is full. Manual switches on both conveyor control and pallet loading machine panels can be used to stop any trunk conveyor.

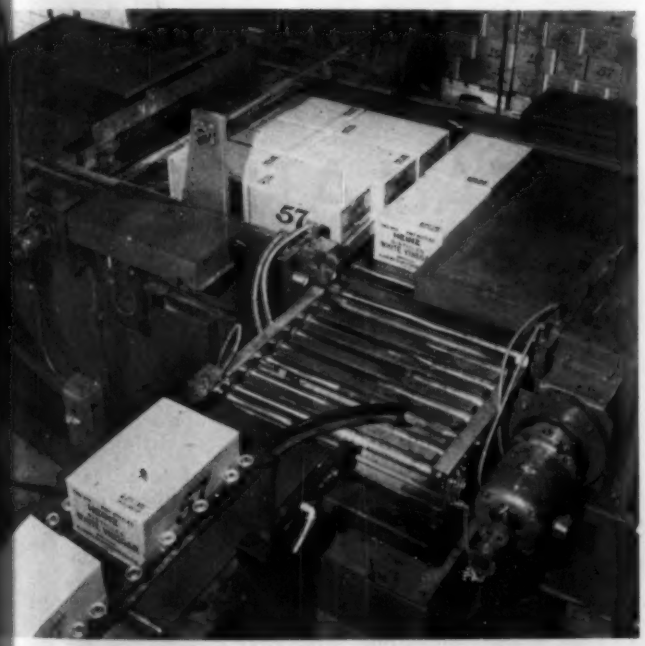

Fig. 4—Overhead view of Lamson pallet loader showing incoming cases and a pallet layer being formed. After cartons are rotated into proper pattern position, rows are formed by a ram moving cartons at a 90-degree angle to the direction of the feeding conveyor. As rows are positioned on a stripper plate, the layer is formed, stripper plate withdrawn and the layer drops to the pallet or to a previously formed layer of cartons.

Fig. 5—Fork trucks complete the stacking of cartons in the storage area. Fork truck handling equipment includes 18 battery-powered high-lift trucks, five battery-powered low-lift trucks, four engine-powered low-lift trucks and six motorized hand trucks.

Handling of palletized cases out of storage by fork trucks is facilitated by the use of four additional vertical lifts which are located in each of the four corners of the building. These are provided with conveyors on all floors and automatic controls so that fork truck handling operations can proceed without interruption on any two levels. Trucks normally remain on one floor. Most vertical movement of pallet loads is downward.

Railroad sidings of the two railroads serving the warehouse are on opposite sides of the building with a 12 foot difference in level. Since these sidings are located on the first and second floors, pallets can be stored only two high on the first floor. However, in the event of a repetition of previous high water levels of the Allegheny River, the relatively small inventory could be moved quickly to upper floors.

Twelve car spots served by the B & O Railroad on the south side of the building are accessible to the first floor, and 15 car spots served by the Pennsylvania Railroad on the north side of the building are accessible to the second floor. On the west end of the building there are garage facilities and truck loading docks for 22 local delivery trucks. There are 24 spots for highway trucks on the east end of the warehouse, ten of which are accessible to the first floor and 14 to the second floor. When operating at maximum capacity, 60 box cars and 69 highway trucks can be loaded daily. Normal two-shift operation provides loading 30 box cars and 35 long-haul highway trucks daily.

The new warehouse handling system has proved to be fully practical from the standpoint of proper return on the capital investment and of savings resulting from the elimination of rent for outside storage, elimination of extra costs resulting from shipping to and from outside warehouses, and of replacement of manual labor with mechanized handling of pallet load units.

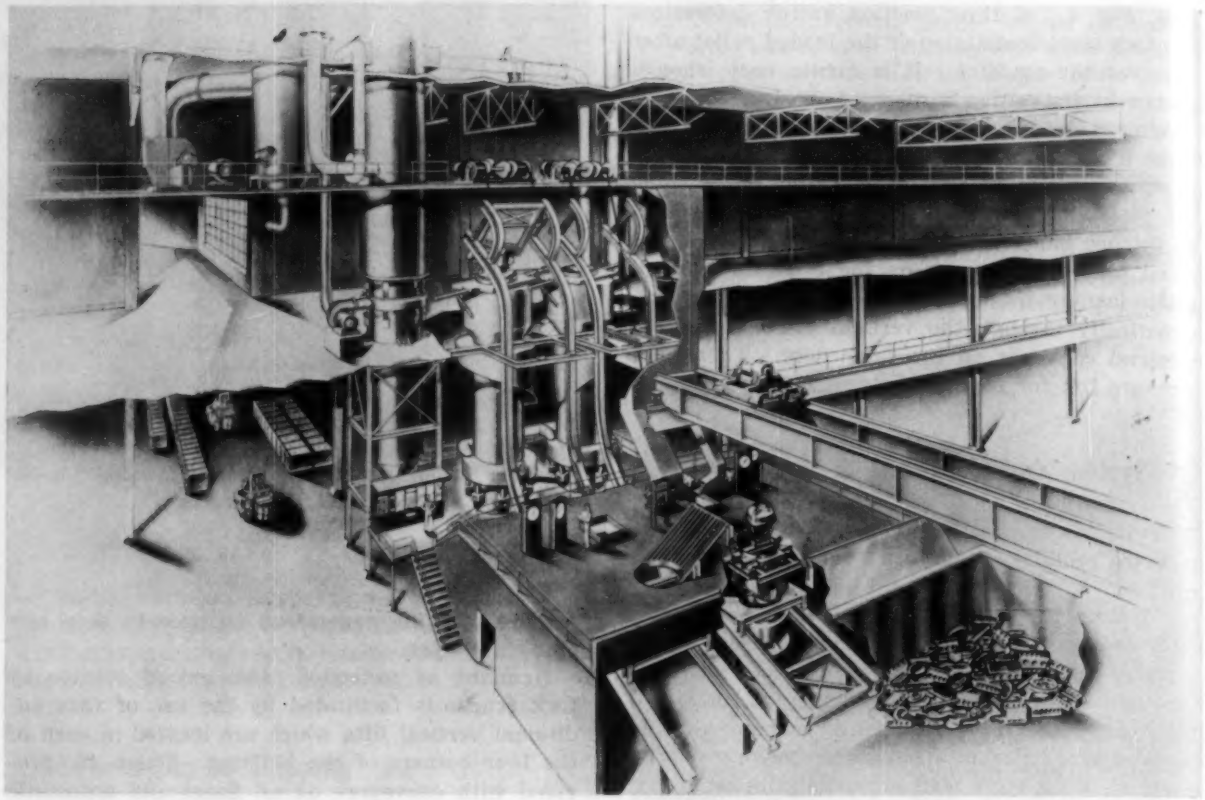

Fig. 1—Stylized drawing of two of the four cupolas at Ford's Dearborn iron foundry installed by Modern Equipment Co. Charging bucket is filled in superstructure at lower right and then raised up the S-shaped tracks to top of cupola to complete automatic charging cycle.

TOP LOADING

SEALED CUPOLA INSTALLATION

UTILIZES AUTOMATIC CONTROLS

By C. E. SMITH
Application Engineer
Cutler-Hammer Inc.
Milwaukee, Wis.

Simplification of the handling of raw products in the preparation of molten iron and elimination of air-contamination by waste gases associated with the melting process—both important considerations in cupola installations — can be achieved with automatic controls which properly sequence and synchronize the various operating units. An automotive cupola installation illustrates "how."

MATERIALS handling and atmospheric contamination are, historically, two major problems associated with cupola operations. Continuous operation of a cupola during a normal run requires frequent recharging with balanced quantities of metal, limestone, and coke. Waste gases associated with the melting operation are combustible and contain large quantities of solid material such as soot and fly ash. Much of the community and individual dislike of foundries in general is created by older installations where waste gases are discharged directly to the atmosphere and escape into the foundry proper during charging through side openings in the cupola.

Considering the current interest in controlling atmospheric contamination and making materials handling a more automatic operation, it is not surprising to find automation represented in a modern cupola installation designed with these goals in mind. The modern installation is represented by four sealed-top cupolas, utilizing a recuperative hot blast system and equipped with automatic electrical controls, which have been in operation at the Ford Motor Co. Dearborn iron foundry for approximately two years, *Fig.* 1.

Charging Operations

One of the unique features of this installation is the means of charging the cupolas through the tops which are normally sealed; in this respect the design is similar to blast furnace practices. Each cupola is charged through sliding doors on the cupola top from a charging bucket carried on a skip carriage which is hoisted and lowered by an electric cable hoist unit mounted above the cupola. Each bucket is provided with a cone-shaped bottom which can be lowered when the bucket is in the charging position on top of the cupola.

When the skip carriage is fully lowered, the charging bucket is positioned under a weigh hopper from which 5000 pounds of metal are dumped. The skip carriage is then hoisted a few feet until the charging bucket is positioned under a second weigh hopper from which 600 pounds of coke and 125 pounds of limestone are dumped. The preset weights of coke and limestone have been automatically fed into the weigh hopper from vibratory feeders connected to large storage bins. These in turn were filled from a conveyor belt which runs

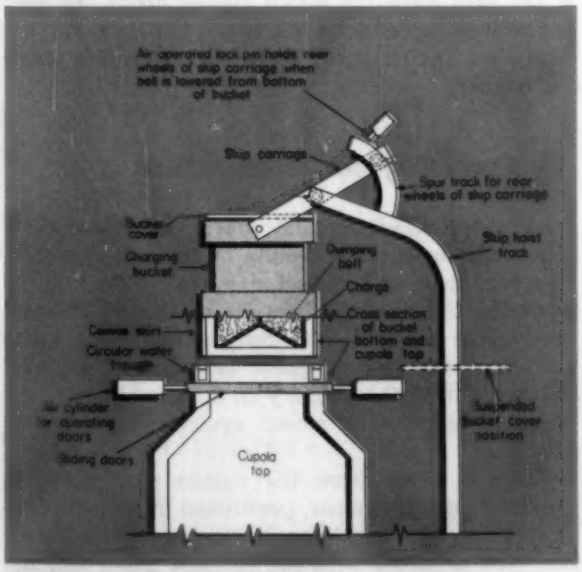
Air operated lock pin holds rear wheels of skip carriage when bell is lowered from bottom of bucket
Skip carriage
Spur track for rear wheels of skip carriage
Bucket cover
Charging bucket
Dumping bell
Skip hoist track
Charge
Cross section of bucket bottom and cupola top
Canvas skirt
Circular water trough
Air cylinder for operating doors
Sliding doors
Cupola top
Suspended bucket cover position

Fig. 2—Method of sealing cupola top while dumping charge is shown. In sealing top bucket cover is automatically picked up by moving bucket; seal between bucket and furnace is obtained with canvas skirt which fits into the water trough.

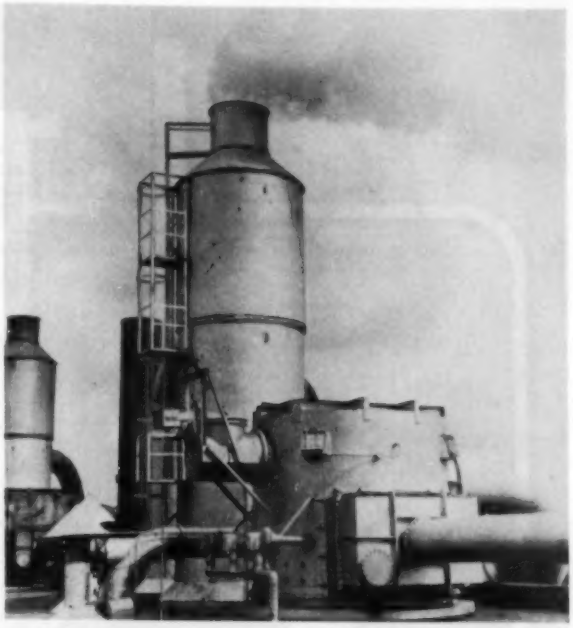

Fig. 3—Effectiveness of air contamination control is indicated by clean, white plume which is emitted from stack and evaporates readily. Multi-wash collector was made by Claude B. Schneible Co.

the full length of the foundry above the cupolas. An electrically operated tripping device running on tracks can be positioned to fill any one of the numerous storage bins from the single conveyor.

After being filled with the proper proportions of coke, limestone and metal, the charging bucket is hoisted to the top of the cupola where the rear wheels of the skip carriage engage a curved spur track such that the charging bucket swings over and down on top of the cupola. When the rear wheels of the skip carriage reach the end of the spur track, an air operated lock pin is inserted behind the wheel to hold the carriage in place.

Before charging the sealed cupola, it is necessary to establish a seal around the charging bucket. To accomplish this, a circular canvas skirt around the bottom of the charging bucket enters a circular water tank set on the cupola top so as to form a seal between the bucket and the cupola top, *Fig.* 2. A circular metal ring around the bottom of the canvas skirt insures that the skirt is always circular and will submerge in the water tank. A metal cover for the charging bucket, normally suspended between the vertical sections of the skip hoist track, is automatically picked up by the bucket on the way to the top of the cupola. This cover is automatically removed from the charging bucket on the return trip to permit the next charge to be loaded into the bucket.

In the charging operation the air operated sliding doors on top of the cupola are opened and the bottom of the bucket is lowered to deposit the charge in the cupola. After a preset dumping time the cone is hoisted, the cupola top doors are closed and the lock pins are pulled from behind the carriage rear wheels. The carriage and bucket are then

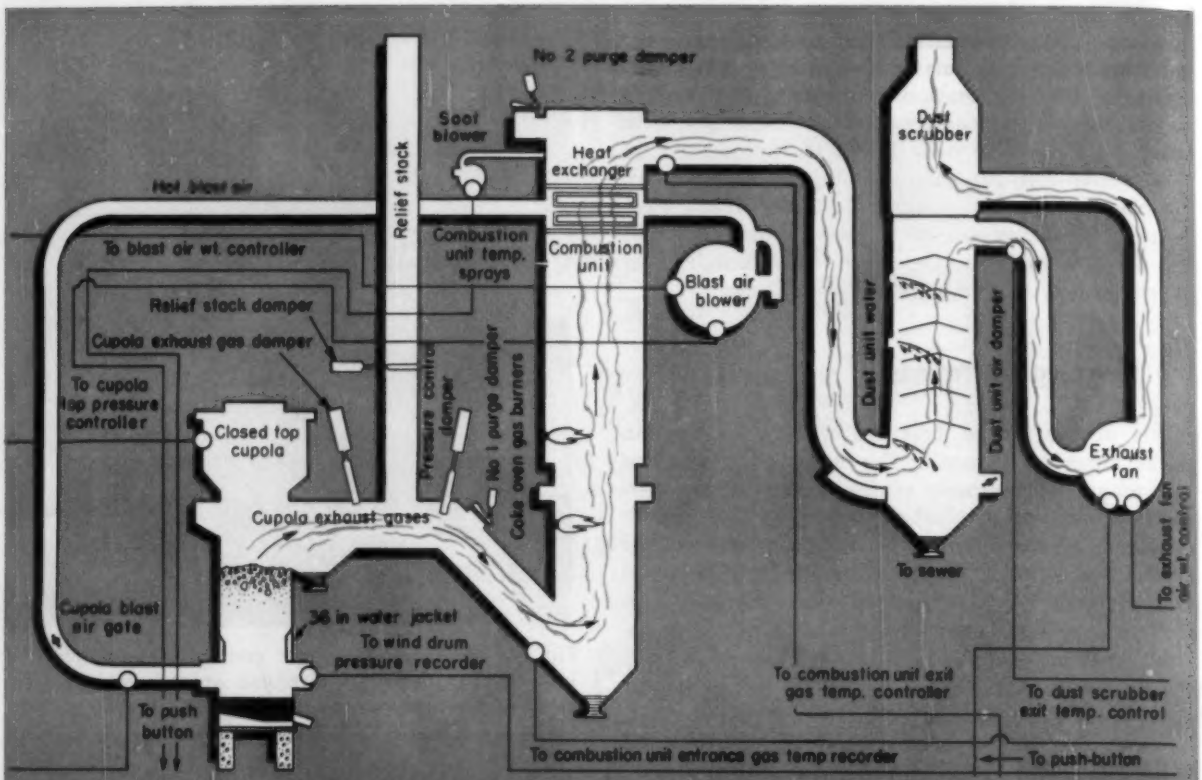

Fig. 4—Schematic diagram of sealed top cupola with recuperative hot blast system. Gas burners in the combustion chamber of the Kewanee-Ross Corp. heat exchanger utilize coke oven gas from ovens located near the foundry.

lowered to the weigh hoppers to be refilled.

Each cupola is provided with stockline indicators to determine when the burden in the furnace reaches a certain maximum level. These indicators consist of air operated rods which are automatically inserted through the side of the cupola before each charging trip of the skip hoist. If the rods strike the burden inside the furnace, the skip hoist is automatically prevented from taking a new charge to the top; but if the stockline rods do not touch the burden, the skip car continues its trip.

The entire charging cycle is automatically controlled by limit switches in conjunction with a relay panel. All that is required is that the operator initiate each charging trip by pressing a pushbutton. If the stockline indicators permit, the skip car travels to the cupola top, the various intermediate operations automatically take place, the cupola doors open and the bell is dumped. The reverse cycle is then completed and the car automatically returns to the metal weigh hopper to be filled again. The skip hoist runs at 70 feet per minute and completes each weighing and charging cycle in less than 3½ minutes. This charging rate is more than enough to keep up with the capacity of the cupola. Manual buttons are provided so that all these operations can be controlled by the operator in case of a failure in the automatic system. Pushbuttons are provided on the charging floor for opening the weigh hopper bottom doors and initiating the automatic coke and limestone weighing cycle. As safety features, the skip hoist controller is electrically interlocked to prevent overtravel of the carriage in either direction and to prevent operation of the hoist unit if slack cable is detected. Other interlocks prevent operation of the skip when the weigh hopper doors are open and prevent opening of the weigh hopper doors except when the charging bucket is in position under the hopper.

▶ Controlling Air-Contamination

Increased efficiency and control of atmospheric contamination are the results of the two recuperative hot blast and collector systems designed to serve the four cupolas. Basically, these two units recover the heat from the combustible waste gases and clean the burned gases before they are discharged out of the stack, *Fig.* 3. A schematic diagram of one of the closed systems is shown in *Fig.* 4.

Exhaust gases from the cupola pass under a pressure control damper, positioned by a hydraulic-electric pressure regulator, into a combustion chamber. Air is mixed with the exhaust gases and the mixture is ignited by gas burners around the periphery of the combustion chamber. The temperature in the combustion chamber is regulated between 1200 and 1500F by the introduction of controlled amounts of combustion air. Water sprays

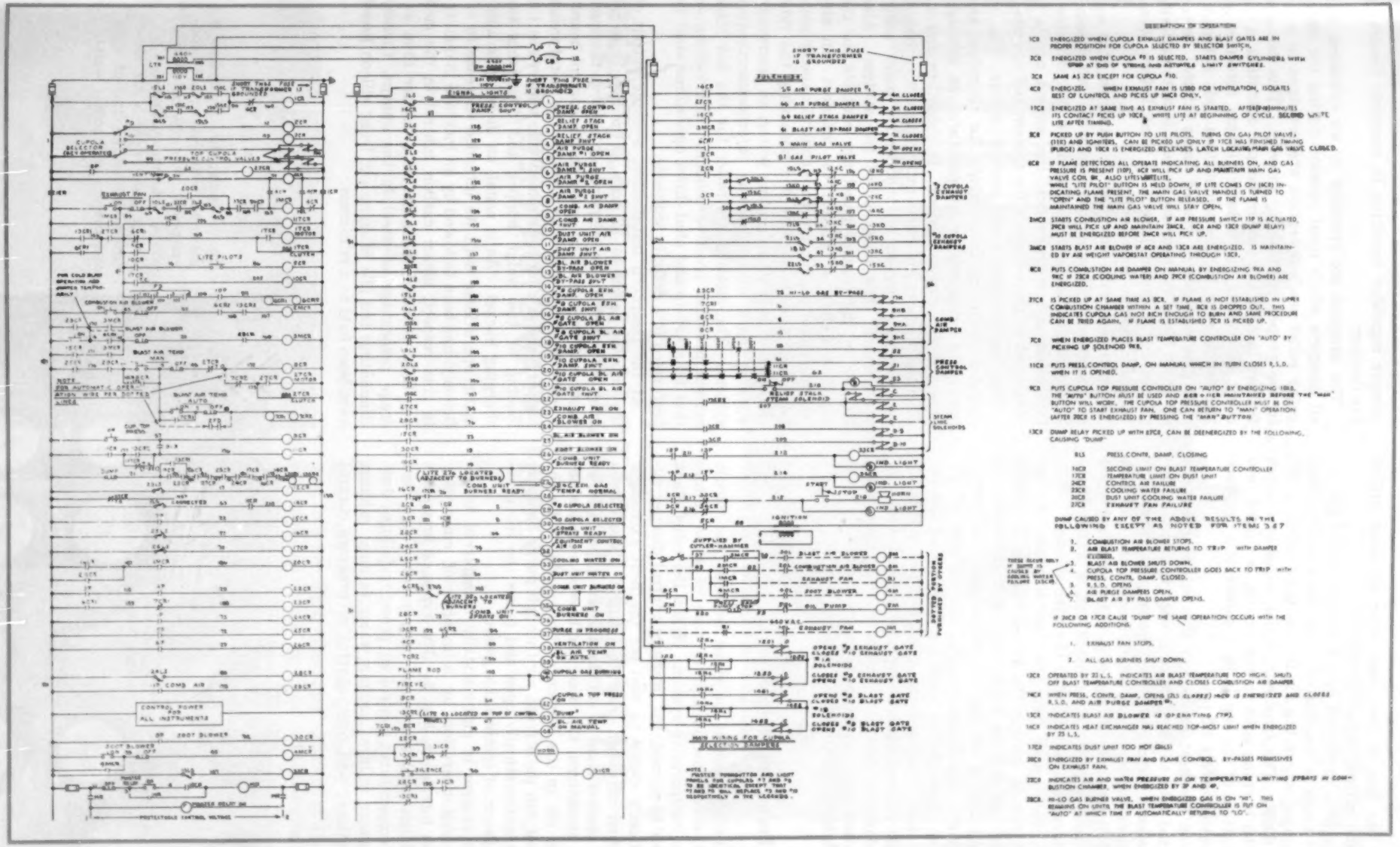

Fig. 5—Schematic diagram of hot blast controller supplied by Cutler-Hammer Inc. Units provide positive sequence interlocking such that all start-up and shut-down operations are performed in a definite sequence.

near the top of the combustion chamber afford maximum temperature protection.

The heat developed by the combustion of the exhaust gases is transferred to the blast air in a heat exchanger where the air is heated to between 400 and 600F. The blast air, which supplies oxygen for the burning coke in the cupola, is forced into the bottom of the cupola by a blower at a pressure of approximately 1.5 psi.

From the heat exchanger the burned gases are directed into the bottom of a wet-type dust scrubber where these soot laden gases pass through a series of water sprays which remove the soot and sluice it into a settling basin. The scrubbed gases then pass through an exhaust fan, a water disentrainment stage, and into the atmosphere.

As can be seen from the flow diagram, the exhaust fan is pulling the cleaned gases from one end of the system while the blast air blower is forcing heated air into the other end. Automatic air-weight regulators control the volume of air passing through the blast air blower and the exhaust fan. The delicate balance between exhaust fan air volume, blast air volume and pressure control damper position is automatically maintained by closed-loop regulators to insure a negative pressure inside the cupola.

Protective Features

A relief stack is provided between the cupola and the combustion unit in case of some failure in the recuperative system. When the relief stack damper is opened, the pressure control damper automatically closes to seal off the heat exchanger and dust scrubber from the cupola. The cupola then operates as a standard open type. Under these conditions, the blast air blower supplies unheated air to the bottom of the cupola, while the exhaust fan pulls fresh air through purge dampers which automatically open and purge the recuperative system of combustible gases.

The system is automatically transferred to relief stack operation by a number of emergency control interlocks, *Fig.* 5. The types of interlocks are: High combustion unit temperature; high dust unit temperature; control air pressure failure; dust unit water failure; cooling water failure; exhaust fan failure; and over control of pressure control damper regulator resulting in complete closure of the damper.

The dampers are operated by air cylinders, and all dampers which must operate during the emergency relief stack operation are arranged to move to the proper position by gravity. This fail-safe feature insures the proper damper operation in the event of control air failure. Flame detectors on the gas burner in the combustion unit automatically give warning in case of flame failure. In the event of flame failure, the system is automatically purged for a preset length of time, before allowing the burner to be re-ignited.

The cupolas are installed in pairs so that one recuperative system can be used with two cupolas. When the first cupola is shut down for refractory inspection and maintenance, the second cupola is connected to the recuperative system and operated.

The cupola operator's control center, *Fig.* 6, contains recording instruments for recording and indicating pressures or temperatures at strategic points in the cupola system. Pushbuttons and indicating lights to aid in operating the entire system are centrally located on the control panel under a schematic flow diagram of the system. Also located on the control panel are controls for the blast air-weight regulator, the exhaust fan air-weight regulator, the pressure control damper position regulator, a window for observing the flow and temperature of all cooling water, an emergency warning horn and telephone intercommunication system. The electric controller for the hot blast system provides positive sequence interlocking so that all start-up and shut-down operations must be performed in a definite sequence.

At the Dearborn installation, average output of the cupolas is 30 to 32 tons of molten iron per hour. Three men are required to achieve this production: The cupola operator at the control board; a crane operator to deliver metal to the metal weigh hopper; and a charge trimmer who supervises the loading of the weigh hopper and dispatches the charging bucket. As is usual, an increase in automatic operations, with its intended increase in efficiency, has been followed by an increase in quality. In this respect, closer carbon control in the melt has been obtained with use of a higher than average percentage of steel in the charge, thereby eliminating the use of some pig iron; silicon losses have been held to a minimum.

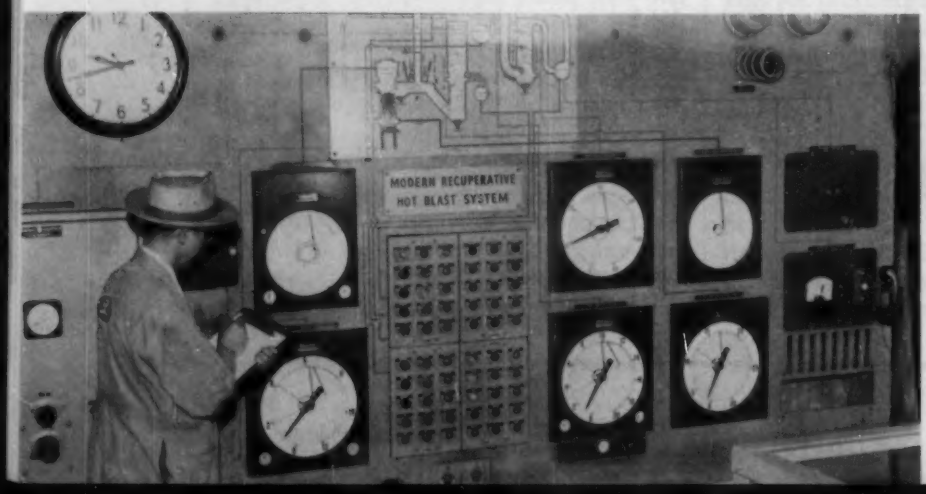

Fig. 6—Each pair of cupolas is provided with this type of control panel. Window below telephone intercommunication system at lower right is for direct observation of the flow of eight test streams of cooling water.

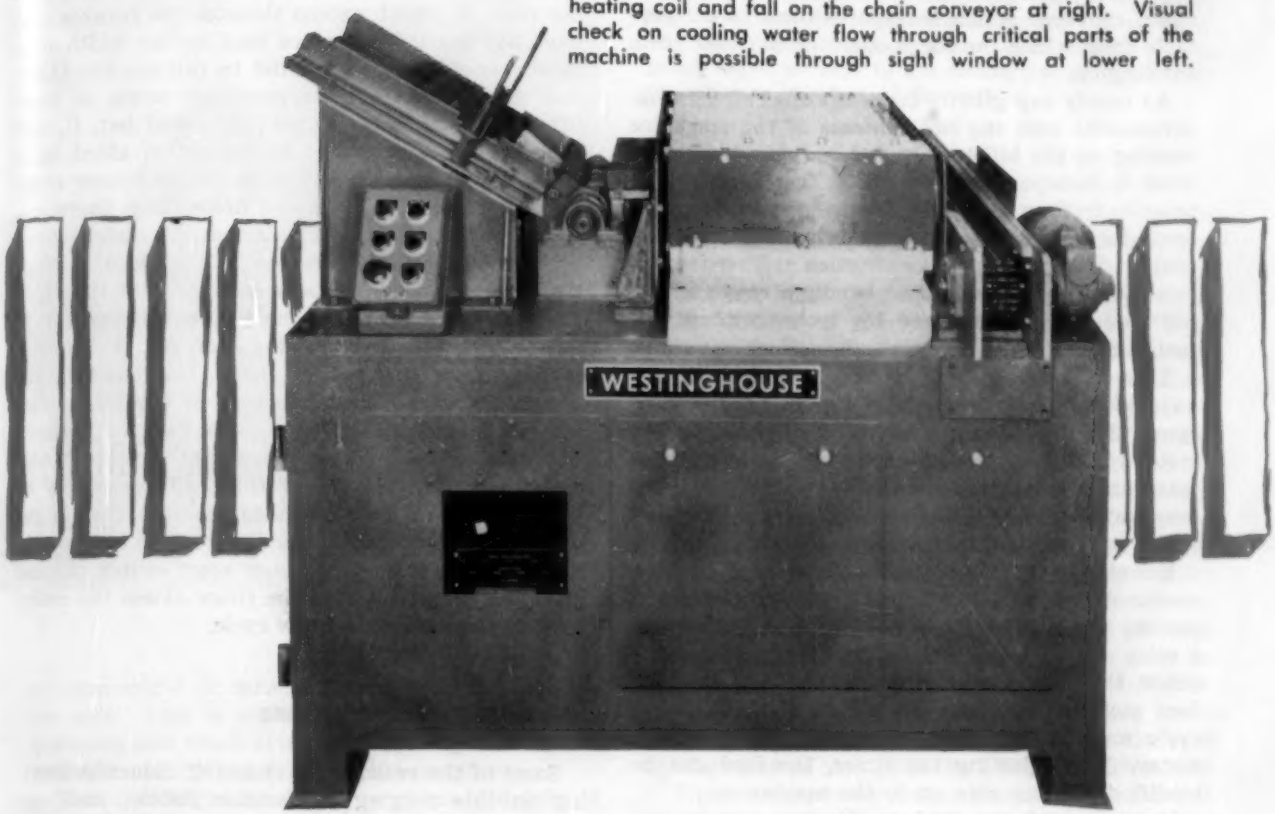

Fig. 1—This induction heating machine was developed to rapidly heat billets for a forging operation. Billets placed in the gravity chute at left are fed through the induction heating coil and fall on the chain conveyor at right. Visual check on cooling water flow through critical parts of the machine is possible through sight window at lower left.

EFFICIENT INDUCTION HEATER

USES AUTOMATIC FEEDER

By W. B. BROWN
Industrial Heating Engineering Dept.
Westinghouse Electric Corp.
Baltimore, Md.

Fast and efficient heating of material for continuous operations is a problem common to many industries. It is one of the major problems in forging operations. In the design described here, a rugged feeder and an induction heater provide the answer to a production forging problem.

REQUIREMENTS IN HEATING billets for forging in a shop making automotive parts illustrate a common heating problem. Production needs involved heating steel billets approximately 1 7/16 inches square by 13½ inches long to a forging temperature of 2350F at the rate of about 300 pieces per hour. The forging shop management specified a variable feed rate, and preferred to load billets by hand into a gravity feed magazine. Space considerations limited the floor area of the equipment to 48 inches by 60 inches.

Billet Heating Answer

Although the equipment size limitations seemed very tight, an induction heater with a sidewise feeding arangement, *Fig.* 1, was developed by Westinghouse Electric Corp. to meet the requirements. A sturdy feeding mechanism receives the billets

from a gravity chute and pushes them through the induction heating furnace. When they emerge from the other side of the furnace they fall on a chain conveyor which transports them to a receptacle from which the forge operator can take them for forging.

As nearly any gravity fed magazine can get temperamental with the full contents of the magazine bearing on the billet to be fed, a separate escapement is incorporated to position the bottom billet prior to feeding. This eliminates interference with feed due to burred edges, interlocking scale deposits, foreign matter or friction. The feeding mechanism was designed to handle a range of bar widths from 1⅛ inches to 1⅞ inches without adjustments.

This feed mechanism is driven from a direct-coupled speed reducer with an output speed of 11½ rpm. Since a high reduction is required in the motor-reducer unit, an overload device is incorporated on the motor mechanism connection rod. This overload device is a simple high angle cam and spring loaded dog arrangement.

Running continuously, this drive could feed a maximum of 690 billets per hour. To obtain a desired feed rate of 300 billets per hour a timer and a relay are employed. On a preset signal from the timer, the relay is energized to start and hold the feed motor *On* for one cycle. At the end of the cycle an adjustable cam cuts out the relay and motor. By adjusting the timer, the feed can be modified for any rate up to the maximum.

Operation of the feed mechanism can be explained by reference to *Figs.* 2 and 3. The "at rest" condition of the feeder is shown in *Fig.* 2. Completion of the pushing phase of a cycle is shown by *Fig.* 3. The cams have just placed a billet on the rails, *H*, which extend through the furnace and have advanced the furnace load by the width of a billet, causing a heated billet to fall out the other end of the furnace. The positioner arms, *A*, have lifted the next billet up past the shear bar, *C*, and over the load stops, *B*. Spring action aided by a pin, *E*, on each cam, *D*, pushes the positioner arms to their raised positions and holds them there until the rollers, *F*, also mounted on the cams, return to their "at rest" positions and drive the positioner arms down. Rotary oscillation of the camshaft is effected through the mechanism connection rod, *K*, and the overload dog unit, *G*. As the positioner arms are pushed down, the billet is released and slides down the tops of the load stops into the feed position on the cams, *Fig.* 2. An auxiliary cam cuts out the feed motor at this point and ends the cycle. Return of the positioner arms to their depressed positions also releases the magazine load, which then slides down to the load stops. This action triggers the timer reset switch, *J*, and after the preset interval the timer closes the relay to start the motor for a new cycle.

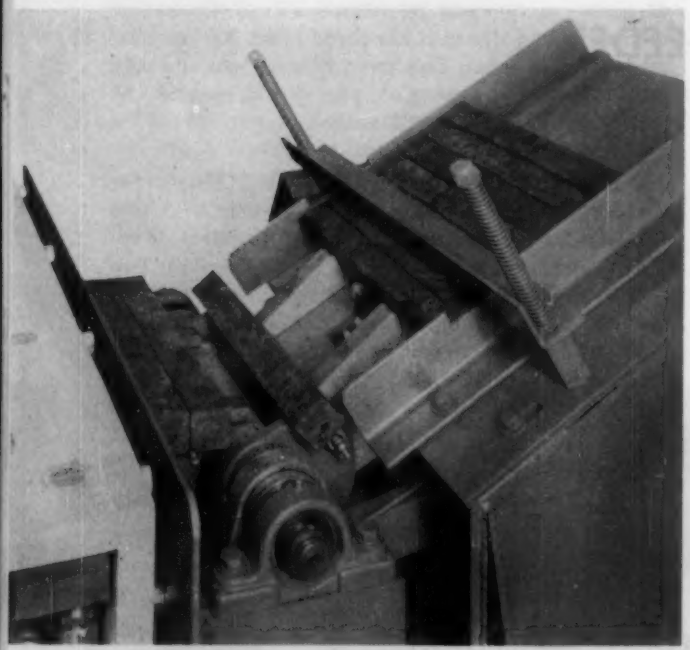

Fig. 2—Feed mechanism in "at rest" condition. Rate of parts feed is varied by adjusting a timer which controls the length of delay period between the completion of one feed action and the start of the next.

▶ Design Considerations

Some of the reasons for choosing induction heating in this forging application follow, and can indicate desirability of a similar solution to other heating problems.

1. In an induction heating application the heat is actually generated inside the workpiece within the close confines of an electrical induction coil. Life of mechanical parts of the heating equipment is improved because there is no large "saturated heat zone". Since the coil is water-cooled an excellent heat barrier is maintained. The only area where intense heat can affect the handling equipment is usually at the discharge end of the heater.

2. Induction heated billets can be available for forging from a cold start-up in a matter of one or two minutes. The induction heating machine can also be shut down just as rapidly.

3. Induction furnaces do not waste fuel to keep the furnace up to a safe stand-by temperature.

4. Induction heating installations require less space for mechanized heating equipment than any other method.

Among the points considered in applying induction heating to this job was the design of the coil unit—an important factor in the effectiveness of the machine. Adjustments to the inductor coil or the generator must be provided for any appreciable change in billet feed rate since this rate governs the required input of electrical energy to the coil. In addition to the electrical problems of conductor sizes and heat distribution, there are mechanical problems of bracing and distribution of the billet weight load.

An important element in induction heating design is prevention of stray heating due to location

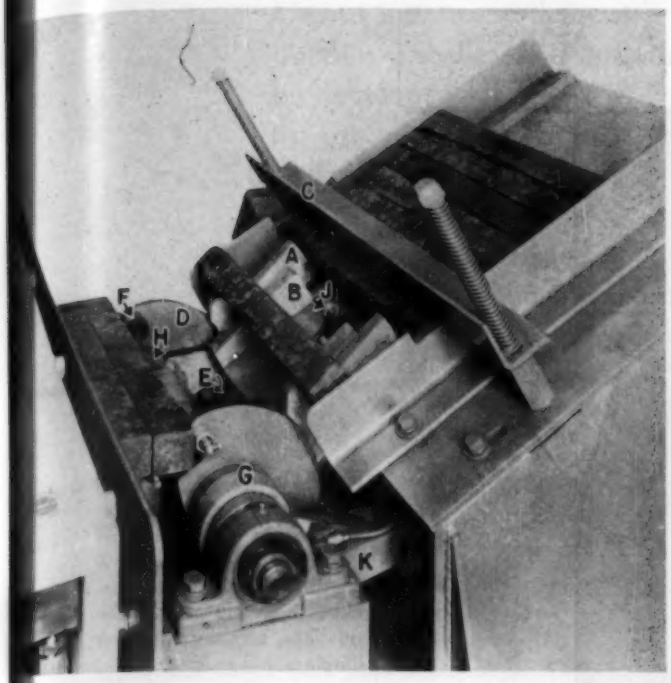

Fig. 3—In feeding, the billets are separated from the stack in the feed chute, one billet per cycle is positioned on the water-cooled rails extending through the heating zone, and the billets are advanced the width of one billet in the heating area. Letters on the photograph serve as keys to the description of the feeder operation in the text of this article.

of mechanical or structural members too close to the coil. This is especially important in low frequencies, and where closed current loops are formed near the coil by the shape of the member.

Special thought must also be given to details of the actual heating chamber inside the coil. In heating for forging, high temperature refractories are specially cast and fitted inside the coil. In some designs, wear strips or rails are employed to carry the workpieces through the coil. This is necessary where it is undesirable for the part to come in contact with the refractory. Even in the case of light parts which can ordinarily be slid across the refractory, the workpiece will pick up a few grains of the refractory and carry them into the forging die, and undue wear and damage to the die may result. Since scale (ferric oxide) and silicon carbide (from which many refractory linings are made) have a strong affinity for each other, it is also usually best to keep parts and refractory separated to minimize buildup which might choke up the clear opening through the refractories.

Rails in the induction heater illustrated in this article are water-cooled. Application of stellite to points of wear on such rails and elimination of any joints in the heating zone greatly prolongs their life. An additional design point which increases rail life is the use of standard cam followers as rollers mounted on the billet feeding cams. These rollers prevent downward thrust on the rails by the cams as they push the billets along the rails.

These observations indicate some of the possibilities and pointers which apply to induction heating units. There are many production jobs in operation or being planned which can benefit by their application. Perhaps some operations in your company fall in that category.

Stationary Image of Moving Web

VISUAL inspection of a web moving at production speeds is possible by use of a device manufactured by National Laboratories & Mfg. Corp., Ridgewood, N. J. The Scan-A-Web is based upon the principle that a mirror rotated at a certain related speed will give a stationary reflected image of a moving object.

In this inspection unit, a series of strip mirrors are mounted to form a many-sided drum. This drum is turned by a Selsyn motor which is electrically driven by another Selsyn motor that is geared to the press at some convenient point. This drive gives continuous synchronism at all web speeds from one to more than 1000 feet per minute.

Detailed inspections of the moving web are possible by use of a supplementary magnification system which provides for magnification up to 6 power. Special lighting fixture provides for viewing of surface and reverse printing on a clear web.

In a typical installation, the Western Waxed Paper Div., Crown Zellerbach Corp. has installed a unit on presses preparing wrapping material. Printing register, general reproduction quality, and color intensity are more easily controlled during press operations, thereby providing for increased quality with reduced downtime. Color inspection is expedited by a provision for comparison in which approved color sample is affixed to the scanning device.

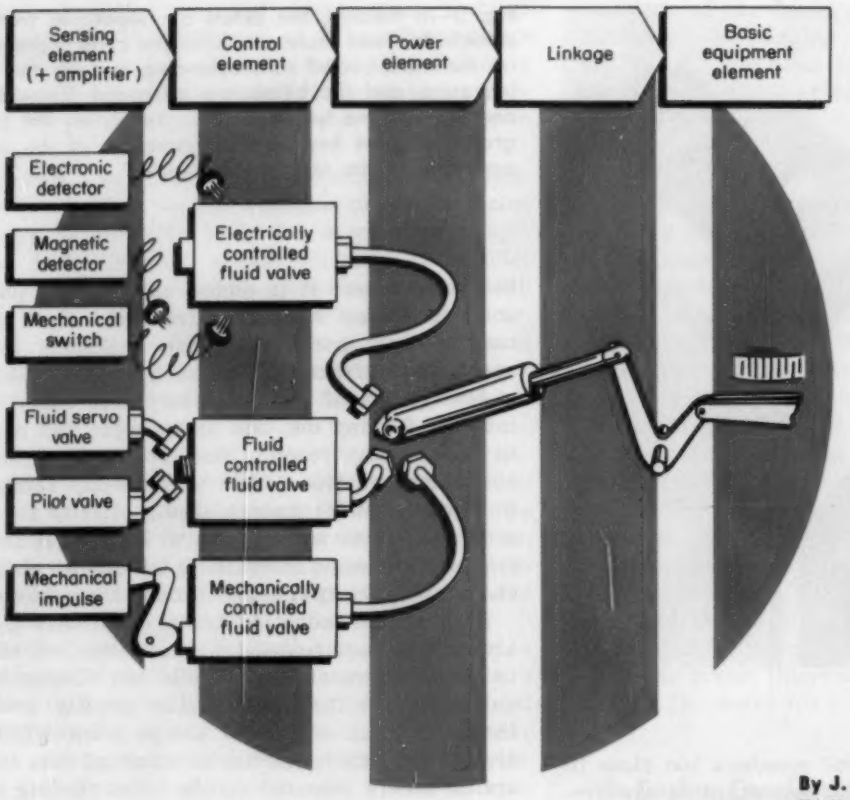

Fig. 1 — Components of automatic actuating devices can be roughly classified as shown. A great variety of components is available and the possible combinations are limitless.

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AUTOMATIC ACTUATING DEVICES

SIMPLE THINGS—equipment auxiliary to process machines—are the object of this discussion. The subject discussed is automation in short steps. We shall call it progressive automation. What we shall do is to remind ourselves of what we already know and understand, and can make use of when the heavy intoxication of electronic brains has worn off. For the most part, we contend, industry will proceed by advancing further the processes of mechanization. Most of us for a long time to come will fall a long way short of automation—as the purists would have it.

Whereas the new factory to produce a new product—or for that matter an old one—may be designed from first principles and may be as automatic as investment policy and technological advances will allow, the immediate and common problem of manufacturing is to increase the productivity of a limited labor force, to a great extent within the limitations of available machine tools and accepting for the present the form in which semiprocessed materials are supplied. It is not only that there is a shortage of labor. The shortage also involves the degree of available skill. Many repetitive operations involve skill—not alone, but skill coupled with the exercise of great care, which is even more important in many cases.

Automatic work handling machines can now be designed to produce at an economic cost to a standard of accuracy matched, if at all, only by skilled operators working with great care. There is also, therefore, opportunity for quality improvement over manual levels. It derives from the fact that consistent placement, location and holding of the workpiece form the basic design criteria of such automatic machines. Constant output is achieved by the same means at the optimum rate of the machine. Scrap is reduced by the consistently accurate placing of the parts. The operator is out of harm's way, and therefore comes to no harm. His labor and his skill can be conserved—to be used where it is really needed.

Based on a paper presented at the conference of the Institution of Production Engineers, June 1955 in Margate, England.

Use of automatic devices is not limited to massive production installations. Automatic physical processes can be developed for small as well as large scale operations by use of power units and associated sensing, control and linkage elements to produce necessary movements. Some of these elements, considerations in applying them to actual equipment, and examples of such applications are discussed and illustrated in this article, with special reference to devices using air as a medium.

The trend for him is upward—for example in setting, inspection, maintenance—hence the need for more technical training and personal development.

The nature and extent of capital re-equipment to achieve the dual objectives of higher productivity and lower cost plus other objectives in any particular case involve a balance of considerations. Simple movements can be reproduced. Some of the frailties of human nature can be avoided. True, other problems take their place. It is for a developing engineering skill to reduce them to a minimum. At this stage the watchwords, both for the designer and the user are simplicity, reliability, ease of maintenance.

Progressive or step by step automation can be applied to good effect to an existing production unit in the automatic handling—loading, unloading and transfer—of the workpiece, in conjunction with existing standard machinery or special purpose units. There are some objective advantages. The production engineer has the opportunity of selecting in priority those points in the production cycle where the greatest gains can be obtained in return for the effort and capital expended. Benefits can be obtained with minimum dislocation to current production.

However, a word of warning is indicated. Precisely because the possibilities are endless, because an extraordinarily high virtuosity in design can be acquired, it is all the more necessary to be disciplined in the multiplication of devices and not to employ them for their own sakes. Self-discipline is also forced by the need to conserve the skilled staff available for design, construction and ultimate maintenance of such equipment.

Power clamping of the workpiece, now a commonplace element of jig and fixture design, has made an important contribution. Effort has been saved in loading and release; manual movements have been reduced; the speed of operation increased. Other advantages have accrued. Clamping loads, for example, can be adjusted to avoid damage to the workpiece—and, especially valuable in close limit work, the clamping load can be applied to avoid distortion, consistent with a safe hold. In many cases the distribution of work over the production cycle has made it possible for the operator to handle additional machines.

As machines and cutting tools were developed to take heavier cuts, power clamping helped to bring down the cycle times. In the case of compressed air operated fixtures the use of exhausting air has been developed to obtain automatic ejection of the workpiece and clearance of swarf, thus gaining additional advantage at low cost.

In the dial feed press where the operator loads the blanks into recesses in an indexing table, mechanically operated by the press itself, a pointer to the trend can be seen. The cycle time is governed by the optimum rate of the press; the loading is not a factor in the cycle; the operator is safe.

As transfer and work handling devices increase their range of movement, the simple linear or ro-

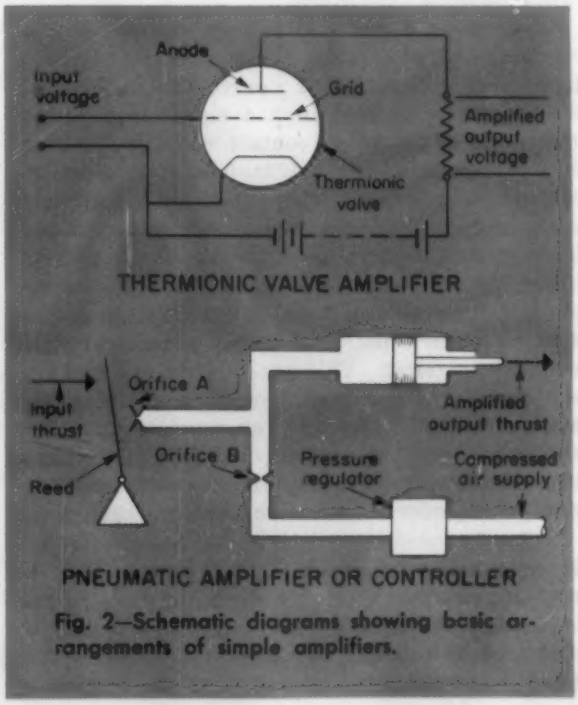

Fig. 2—Schematic diagrams showing basic arrangements of simple amplifiers.

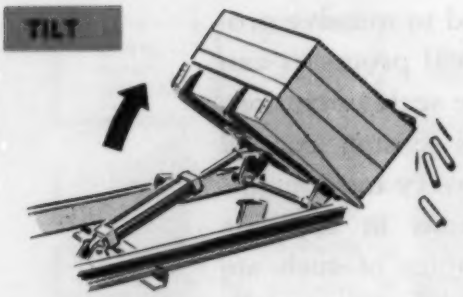

Fig. 3—One stroke of a cylinder moves a full bin then tips the contents into a hopper.

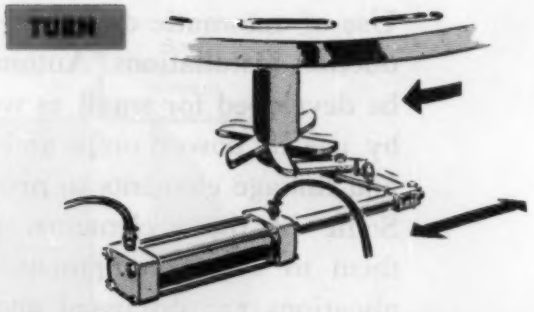

Fig. 4—A simple automatic transfer machine may consist of machine heads mounted above a turntable which is indexed by a star-wheel mechanism.

tary motions which actuate them become more complex primarily by reason of combination and, only to a limited extent, in themselves.

In many cases they include some form of sensing element remote from the point of application and thus by a different route, still retaining an essential simplicity and at low cost, they approach more nearly the fully integrated automatic machines. This line of thinking applies, for example, with particular force to power presses.

Elements of Linking Devices

However, whether they be devices which push, pull, lift, lower, turn or tilt; which transfer from one process to the next, or from one conveyor to another; which unload one machine and load the next; which clamp quickly and loosen equally quickly—or even genuflect on Sundays, the elements embodied in them are for the most part common and may be classified under general function groups outlined in *Fig.* 1.

Movement of material or components may at one stage of processing, be required to control a later stage, possibly to operate some selective mechanism or to feed back a signal to a master controller. If physical contact with the material or components is undesirable, it will be necessary to produce an impulse which does not depend upon such contact. In this case some special means have to be found to use some kind of proximity effect. A common detector of this type is the photoelectric cell. A beam of light is used to produce an electric potential across a piece of light sensitive material. This potential is too small to use directly in the operation of an actuator, but may readily be amplified electronically. Other electronic detectors may use change in capacitance of a condenser system, or change in resistance of a conductor, under stress or temperature change.

A further possibility is that the presence or absence of magnetic material in a process may be made to produce a control signal by varying the inductance of an ac system. This signal may be increased by means of a magnetic amplifier. This gives a more rugged system than the electronic, but with some penalty in the rate of response.

An interesting detector useful to the development of automatic controls, which does not use electricity and yet has only the slightest disturbing effect on the material or process, is the pneumatic amplifier or controller. In this device a small air flow is passed through a pressure regulator and two orifices in series. The movement of a flapper close to the second orifice varies its resistance to the air flow and so varies the pressure between the orifices. By applying this variable pressure to a large diaphragm or piston, a small movement of the flapper may produce a large mechanical thrust at the piston. The same basic principle is used in pneumatic gaging, which may be built into the system. In this case the air pressure variation may be made to operate a fluid valve and cylinder to divert gaged components into different routes according to size. In *Fig.* 2 there is illustrated, in outline, the basic arrangements of both the thermionic valve amplifier and the pneumatic amplifier.

In considering control elements for automation, it is important to appreciate the factors affecting the speed of response of the control element to the incoming signal. In general the most rapid response is obtainable with a thermionic valve of the thyraton type. If, however, the amplified current is required to work a magnetic system, the overall gain in time by the use of electronics is small. For maximum speed of response of electromagnets and solenoids, the signal must represent an over-voltage compared with the normal rating of the coil, to ensure rapid buildup of the field. An automatic switch operated by the response of the magnet system will then be used to limit the signal voltage to a safe level. Pilot operation of an air control valve can be extremely rapid, but the rate of response decreases with pipe length. The authors are in favor of penetrating the design problem as deeply as necessary to get the simplest solution. For example, it is clearly an advantage to use direct mechanical operation of the control valve from the "parent" machine or component or, failing that, the mechanical operation of pilot valves or switches which in turn actuate the main valve.

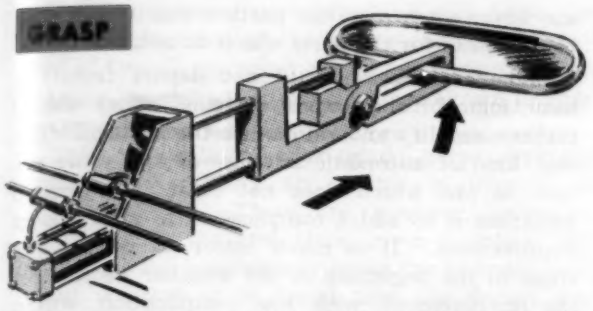

Fig. 5—Jaws are advanced to pickup position by a cylinder and closed by a stop on the guide rod. After transfer by other means (not shown) the jaws open and retract.

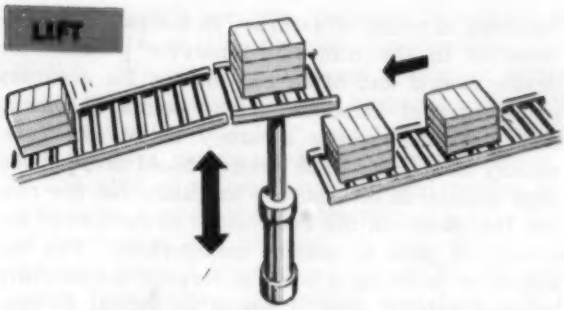

Fig. 6—Section of conveyor track raised by cylinder lifts articles from one level of gravity track to another.

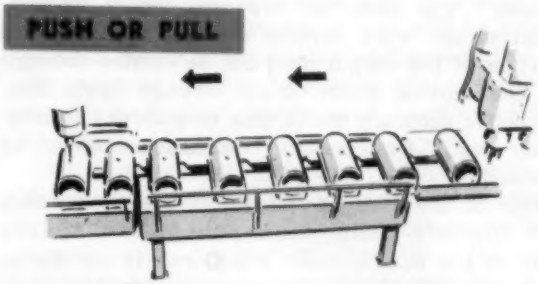

Fig. 7—Workpieces are transferred between operating stations in time with processing cycle by a bar carrying several pawls. The bar is moved to and fro by a cylinder or crank.

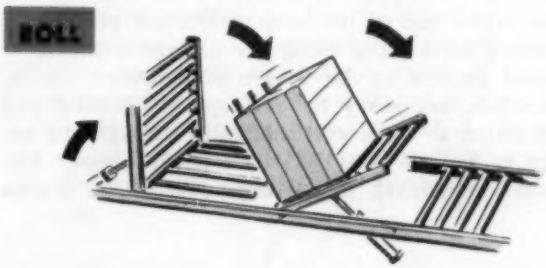

Fig. 8—Heavy or bulky objects are turned over with two L-shaped cradles operated in sequence by cylinders.

Power elements are well known, in common use, and each with their advantages and disadvantages can fairly readily be evaluated in particular situations. For the most part they are motors and linear actuators operated by electric, hydraulic or air power.

Electric motors have the advantage that supply mains are universally available. To some extent this advantage is offset by the difficulty of speed adjustment which is often necessary to integrate the automatic linking device with other movements. Speed reduction units raise the bugbear of complication.

Hydraulic motors and actuators have the advantage of considerable motivating power in relation to size. From the inherent characteristic of the noncompressibility of the fluid comes the advantages of locking and repeatable speed control. On the other hand, compared with an air system, the response rate is relatively slow. A serious disadvantage is that hydraulic power is seldom on tap and requires both a pump and a prime mover to make it available, although these are conveniently available in "packaged units."

Considering compressed air systems, the general availability is an obvious advantage—the relatively low overall efficiency of the system as a means of transmitting power is offset by the inherent elasticity of compressed air, which has the effect that the installed horsepower need only represent the average demand and not the peak. The ease by which energy may be stored in compressed air in this type of application is a point to be studied in relation to electrical and hydraulic systems of actuation and control. The rate of response of compressed air is high. The medium is clean—leakage is not messy, but in this respect has the defect of its merit in that leakage can be—and often is—undetected.

▶ Design Pointers

What we propose to do is to penetrate a different level in seeking to identify some of the design criteria relevant to automatic linking devices and which lie behind their varied external forms. In the authors' experience, most of the design considerations flow in the first place from the requirements of the production time cycle.

Secondly, we should seek to achieve in our automatic device a common level of performance and reliability with the parent machine to which the device is ancillary. This at once involves a balance of considerations. On one hand there is a definite advantage, where rapid movement is concerned, in reducing inertia by lightening. Unnecessary inertia may slow down the time cycle and impose additional stress at starting and stopping. There is a tendency—and it is one to be avoided—to pursue the process of lightening too far, with detriment to rigidity and reliability in operation, and with the attendant risk of the automatic device becoming the weak link in the chain of production.

A more intelligent way of gaining economy is by avoiding in the linking device any unnecessary re-

finement in terms of accuracy in the path of movement or in the control. Wherever possible the device should and often can depend for accuracy upon external locations at the points of pickup and placement where accuracy is, in any case, usually necessary. The device should not embody high standards of accuracy in guides for the reason that between the extremities of movement accuracy of path is usually unimportant. For example, in handling a billet at forging temperature between sets of dies, it would be logical to provide a V-shaped locating surface at each die against which the moving arm of the device would merely exert a constant thrust during the forging stroke. The need for accuracy would be confined to the work holding element and the fixed portion of the die; it need not be carried through all the moving parts of the linkage mechanism. Objective accuracy would thus be achieved at minimum cost. Unnecessary complication would be avoided.

One of the many detail design problems which will illustrate a more basic point, is how to take care of the flexible hoses which run to the air or hydraulic actuators. In many cases they have to move in sympathy with elements of the mechanical linkage, and unless the run of the hoses is so planned as to avoid severe bends, they may prove to be a point of weakness. It may well be that wider use of the modern aircraft practice of running rigid pipes along the linkage elements to sealed swivels at the hinges is indicated. It is, therefore, necessary by development, testing and prediction to work systematically through the design to remove possible points of weakness. All-around reliability is the objective. Good marks are never given for the parts which work—only black marks for the parts which do not.

Linkage devices should not depart from the basic logic of their work systems. They should further simplify and rationalize the systems. The best kind of automatic linking—or any other device—is one which does not exist. A common weakness is to add a complication to gain a local improvement. It is much better to retrace our steps to the beginning to see whether we can get the improvement, with less complication, within the basic logic of the work system, and devices should, if at all possible, be designed to "fail safe" or at all events, protect the most important point in the system.

There is a golden rule about the mechanical linkage geometry. It should be the simplest form of linkage geometry to satisfy the required result. The objective of the designer is clear. He must, by analysis, establish the elements of work to be done and bring in the smallest number and simplest form which he can conceive. The truly virtuous designer, in short, is simple-minded.

▶ Actuators Applied

Some of the principal criteria governing the design of automatic linking devices have been identified and main elements embodied in them have been examined briefly. Simple movements possible with such devices are illustrated by *Figs.* 2 through 8. Although our examples, and particularly the illustrations, have intentionally shown simple and often single movements, these movements can be combined to produce linking devices

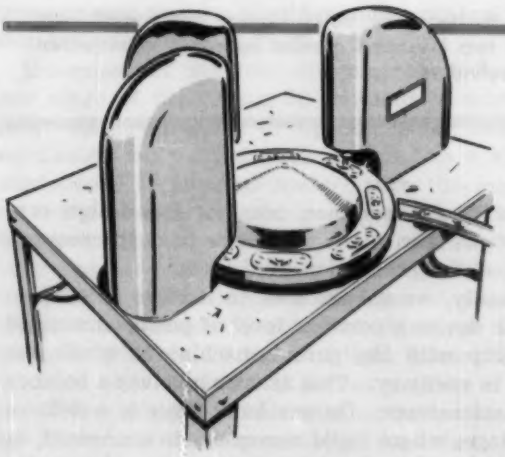

Fig. 9—A small brass forging has to have an irregular internal profile shaved, a central hole reamed and two holes drilled. Compared with a press and two drilling machines linked by transfer devices, a new machine comprised of three heads above an indexing table was faster and cheaper. Table indexing is pneumatic and is started by completed withdrawal of all three heads. Workpieces are automatically ejected by raising of two ejector pins.

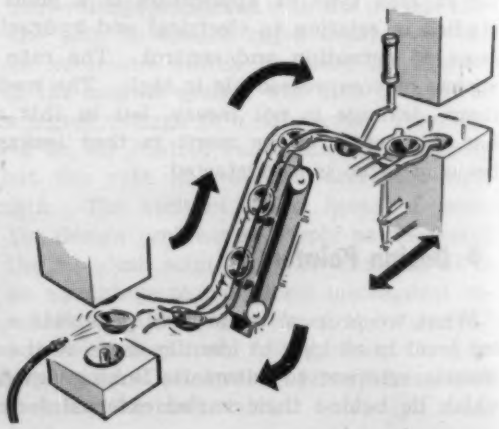

Fig. 10—Four standard presses producing lamp reflectors from steel strip are linked together by transfer equipment. The operations are: Blank and raise, draw, trim, raise and pierce. One ejector pin in the die lifts the pressing clear. A pair of air jets blow the part into a track where paddles on a conveyor belt elevate the piece for gravity feed to the next operation. Released from the track in synchronism with the press, the part is placed in the die by spring loaded jaws which are cam-operated by the press.

of wide range and versatility and still retain the essential simplicity of the basic elements. A number of typical examples of the application of such devices to production machines are shown in *Figs.* 9 through 13.

The applications illustrated were obviously tailor-made: Many are. This is inimical to standardization. There are, however, redeeming features. In the first place, given a design philosophy which consistently seeks the ultimate, simplest solution, it is found that the design conceptions arrived at are capable of frequent translation into the solution of problems which, superficially, vary widely. Recording of information and systematic reference to it when designing and developing equipment will lead to the gradual standardization of basic automation units.

Benefits of automation need not await the existence of the pushbutton factory—nor even the massive contribution which will come from investment in great special purpose transfer machines capable of continuous automatic processing of standard components. The simple and elementary devices which have been illustrated, while providing the basis for elaborate compositions when these are necessary, are applicable in their simple form to many production situations.

Automation, therefore, is within the scope of the small manufacturer and can be applied step by step, progressively or piecemeal—call it what we will—within a reasonably modest program of productivity improvement. What we do in such a program with the aid of automation equipment is primarily to conserve the human effort otherwise applied to the loading and unloading of machines and handling material or components between machines. We can improve quality performance by the consistently accurate placement of material or components as the described applications have shown. We can by continuous cycling of certain types of machines achieve a higher machine utilization factor. Regular interoperation transfer and handling can be used to save factory space.

The kind of automation equipment needed in a particular factory will be determined by the scale of production and the type of products or components passing through as well as by the processes themselves. If existing machines can be converted to automatic operation—this will often be the case with power presses—no major capital investment in special machines is called for. If machines cannot be converted and if special machines cannot be afforded, it may still be possible by such means as automatic loading machines and intermachine linking devices to enable one operator to look after two or more machines instead of one.

Since, in general principle, most operations—processing and handling—can be made automatic, it is usually a question of determining whether it is an economic proposition. Sometimes the matter may not be decided on economic grounds at all. Safety, working conditions, output, or other factors may be uppermost.

One of the main objectives of this article has been to suggest that the benefits of automation are neither confined to the "pushbutton" future nor to the great manufacturing organizations. Simple—sometimes elementary—bases of automation design have been demonstrated to show that a step by step or progressive approach can be made in all organizations, large and small, where economic or other considerations invite such an approach.

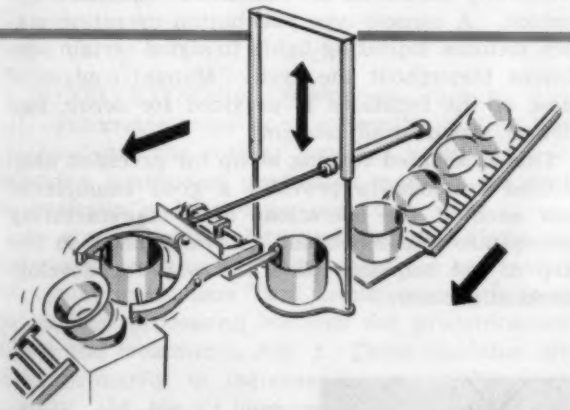

Fig. 11—In an operation to flange welded steel bands it is desirable to steady the band until it is actually engaged by the die—a situation undesirable for manual operation. This feeding equipment was devised to receive bands from a gravity roller conveyor, drag individual bands onto a lift platform, and raise them into position for gripping by jaws which move in and out of the die area.

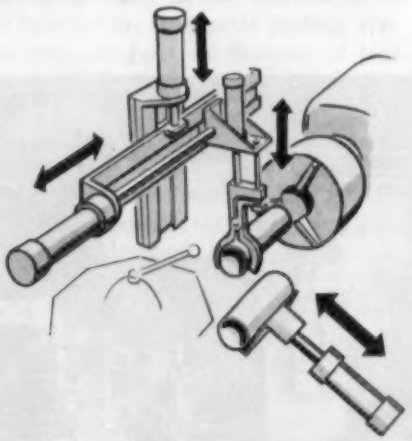

Fig. 12—A hopper beside a lathe carries a stock of blanks, the lowest of which falls into a tray. A cylinder pushes the tray forward and another closes jaws on the workpiece. The tray withdraws; the jaws move to chuck height; then approach the chuck and insert the part. Completion of this approach closes the chuck; the jaws open and withdraw upward, and turning begins. When the cut is finished and the tool withdrawn, the jaws descend, grip the bar as the chuck opens, and withdraw it. As the jaws move from the chuck they drop the part into a chute before returning to their original position for the next workpiece.

TURNING CAST CRANKSHAFTS

MODERN TECHNIQUES of shell molding used to cast crankshafts are being acclaimed by automakers for advancement in product quality and reduction of manufacturing cost. Casting to closer tolerances than were formerly achieved by forging methods allows scrap weight reductions by providing less machining stock on the raw workpiece. In addition to savings in material cost this practice has another advantage—less machining time.

To fully realize the potential of this situation the R. K. LeBlond Machine Tool Co. has developed automated crank-turning equipment to do the initial turning work on cast crankshafts. This equipment consists of three machine units, *Fig.* 1, which take crankshafts that previously had locating spots milled on three lobes and the ends milled and center-drilled.

The first unit is an automatic center-drive lathe that turns all the main bearing diameters and related surfaces that are on the same axis. The second unit is a Sheffield automatic gaging machine to check this work. The third unit is a two-spindle crankpin turning lathe that simultaneously machines all the pin bearing diameters of two crankshafts.

In engineering their machine tools to produce 55 crankshafts per hour with one man operating duplicate sets of this equipment, LeBlond engineers had occasion to look into the history of crankshaft turning. In the early days of automobile manufacturing—about 1906—250 crankshafts could be turned in 18 hours by 23 machines and 23 operators in 4000 square feet of floor space. By 1929, it took three machines and two operators in 600 square feet to turn 250 crankshafts in 18 hours. Today, the same number of crankshafts are turned out in about 4½ hours by the new equipment with one-half the time of a single operator.

These automated lathes are equipped with transfer loading hooks to handle the workpieces to and from the workstations. At the same time that a crankshaft is being picked up from the incoming conveyor to be placed in the chuck of the first machine, the machined crankshaft is being picked up by another set of hooks and will be placed on the vee blocks of the gaging unit. As the new part is placed into the lathe, hydraulically operated centers are inserted into the rough crank in such a manner that the positioning is accomplished by the left center moving in faster than the right.

Machining at this position consists of simultaneously cutting all five main bearing diameters, flange and pilot, sprocket diameter and front end. Rough and finish tools traverse, feed, dwell and retract simultaneously from front and rear of the machine. The machine jogs to a stop with a lock pin determining the correct rotational position. The crankshaft is then automatically unchucked, centers are withdrawn and the loader hooks pick up the part.

As this is accomplished the gaging machine automatically checks the diameters of the number 1, 3 and 5 main bearings and the thrust wall width of the number 3 main bearing of the previous part. If the part is acceptable the gage ejects it to the handling equipment at the rear and signals "all clear." If the part is not acceptable, it remains in the gage and a red light in the panel indicates the faulty portion; functioning of the lathe is held up at this point. When adjustments are made the gage is cleared manually and the machine is started.

Crankshafts with main bearings turned and checked by the gaging unit are delivered to the pick-up stations of the two-spindle lathe. Two parts are picked up by the loader hooks and placed in the chucks while two finished parts are obtained from the chucks and delivered to the outgoing automated handling equipment.

All machine motions are electrically and hydraulically sequenced for continuous automatic operation. A console-type pushbutton operating station includes indicating lights to signal certain conditions throughout the cycle. Manual control of most of the functions is provided for setup, tool change, repair or adjustment.

This automated turning setup for precision shell molded crankshafts provides a good example of how each of the operations of a manufacturing process are interdependent. Advancements in one step of the sequence pave the way for developments at another.

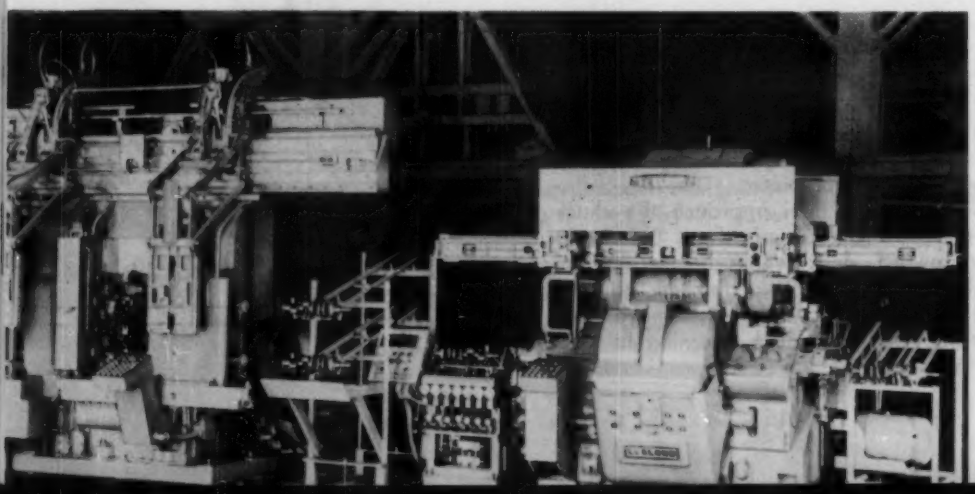

Fig. 1 — Fifty-five crankshafts per hour are completely turned by this automatic LeBlond unit which consists of (right to left) automatic line bearing center-drive lathe, gaging machine and automatic two-spindle pin bearing lathe. Loading racks shown are temporary fixtures for runoff only.

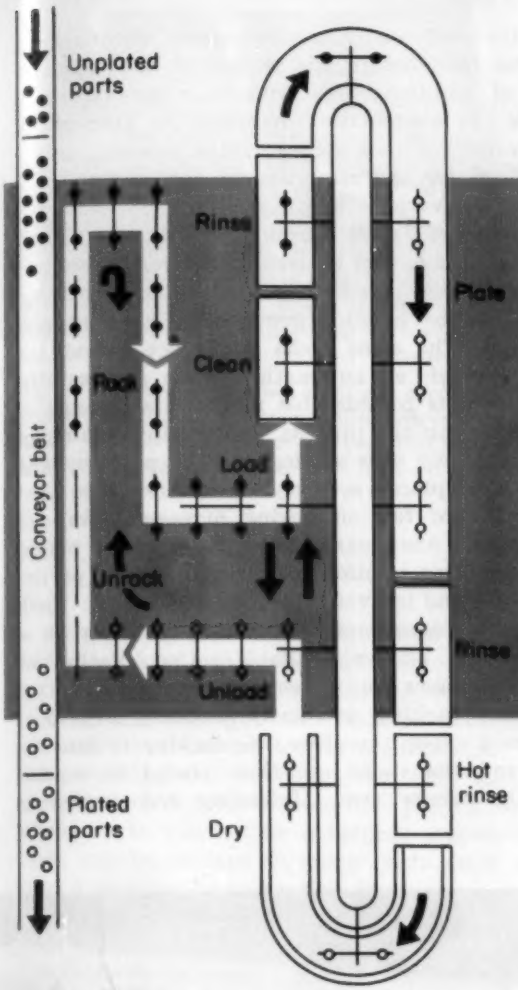

Fig. 1—Completely automatic plating installation would generally include elements shown in this figure. Actual developments in the field are well advanced except in automatic racking and unracking of individual parts.

PARTS HANDLING KEY TO AUTOMATIC PLATING INSTALLATIONS

Automatic plating and solution processing reflect the importance of conveying and handling to the field of automation in general. Significant results are obtained when the individual steps of the process are joined together by a continuous handling installation.

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Consulting Engineer
New Castle, Pa.

CONVEYING of workpieces through the successive steps in an automatic plating line reflects the current progress being made in adapting continuous production methods to what is basically a batch-type operation.

As applied to the plating of discrete objects, an automatic machine is fundamentally a continuous or cyclic mechanism that transports workpieces to various processing stations for predetermined times and treatments, *Fig.* 1. These machines are used primarily to increase output and improve quality. At times, however, automatic or semi-automatic means are a necessity in efficiently handling large or bulky parts, and although there are economic limits, there are no real limits to the size of work or the size and depth of tanks which can be incorporated into an automatic system.

Compared to the conventional manual processes there are a number of basic advantages to an automatic system. Automatic handling of materials on a timed cycle results in better control and thus in more uniform quality. Time and total current in electrochemical processes can be reproduced accurately and easily. Draining, rinsing and drag-over of solution can be standardized for more efficient control and use of solutions and baths. Savings can be realized in floor space, sewers and ventilation. Indeed, in some cases the total installation cost is less for an automatic plating system. Further savings are possible because of less rejects in addition to the obvious substantial savings in labor.

The main disadvantage of an automatic system is that it involves a fixed cycle. The conveying speed of the machine can be changed to increase or decrease processing time, but such a time change will affect all individual steps in the system. Modifications are possible, however, by the use of stops so that entire tanks may be skipped in the cycle or parts may be automatically removed from a tank at some predetermined point. Consequently there is flexibility, but of course it does not approach the operational flexibility of a

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manual process where, for example, a part may be cleaned, precleaned or recleaned if desirable.

Although overall quality is improved with an automatic machine, it is not an answer to serious production quality problems. In short, before a plating process can be made automatic, it should be determined that it can be accomplished satisfactorily by conventional methods. In advancing from a manual to an automatic system, two fundamental questions are involved. Will the process faithfully reproduce? Can the parts be successfully racked?

If the particular plating process in question will reproduce on a set cycle then it can be done automatically. However, if there are variations in the cycle, appreciable variations in proccessing times or special treatments or reprocessing required for some parts, then experimentation will be necessary to determine what is required to standardize the cycle. And if different metals are plated that require different cycles, then automatic plating for all parts becomes less likely, although not necessarily impossible.

The consideration of racking refers to the placement of individual parts on the actual support that moves with the parts through the various processing operations. The plating rack is the key to the overall design on the automatic machine. Not only does the rack size determine space requirements, but the rack design can determine the effectiveness of additional features, such as automatic sprays. In electrolytic processes the current requirements per rack determine the polarity, proper use of anodes and requirements for reversing the current at various steps.

Offhand one might think that the racks used for hand plating can be used for automatic plating. In many cases this is true, but for hand plating, pieces can be handled gently and balanced precariously. The same racks might not convey the parts through an automatic system successfully, since there is considerable motion and change of motion during the process. Automatic racking of parts is hardly ever attempted. The parts usually have to be placed securely on the racks so that they will not fall off during movement through the cycles. Also, parts often have to be placed in a particular position to favor plating of particular areas and to avoid trapping of solution. Rack damage is common so that every position on a rack is not always available. Also, plating of different shapes and sizes makes the design of automatic racking extremely difficult, *Fig.* 2.

In most cases, therefore, the racking is done by hand and the racks are then placed or loaded onto the carrier arm. Unloading and unracking

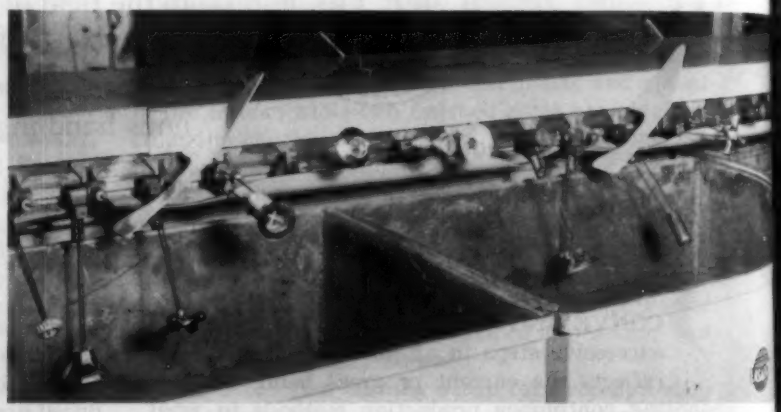


Fig. 2—Variety of sizes and shapes which the typical automatic plating system must handle precludes the use of automatic racking devices.

Courtesy, Lasalco Inc.

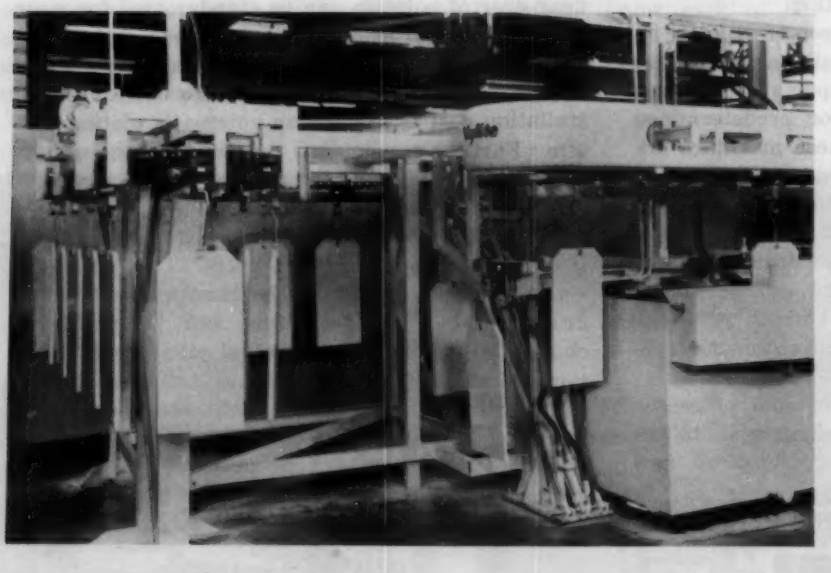
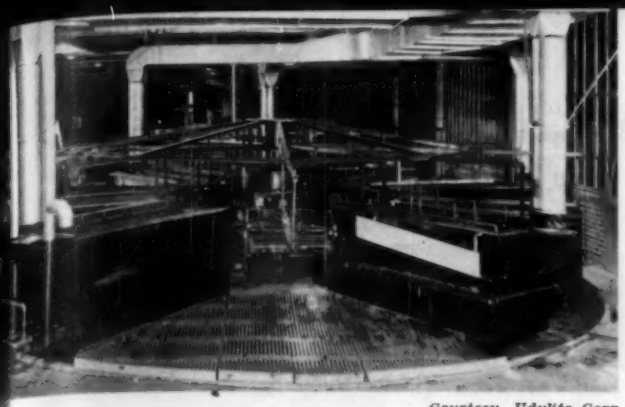


Fig. 3—Automatic load and unload mechanism transfers parts between rack conveyor and plating machine. Parts can be racked and unracked away from the actual plating area and prior to plating operation, can be washed while suspended from the rack conveyor.

Courtesy, Udylite Corp.



Courtesy, Udylite Corp.

Fig. 4—In rotary automatic, tanks are arranged around a central hydraulic cylinder which supports all of the racks. In operation, the entire umbrella type structure raises and indexes from tank to tank on standardized cycle.

is also done by hand. However, automatic loading and unloading of racks onto the plating conveyor can be accomplished by the use of a special rack conveyor and transfer device. Such automatic load-unload devices are available, *Fig.* 3. Hand racking and unracking can then take place at some point remote from the plating machine where parts will not be damaged. Automatic devices can be devised to dump parts from a rack onto a moving conveyor belt for a more complete automatic installation.

In the typical hand installation, as production requirements increase, a point will be reached where conversion to an automatic process will become economic. The decision can often be made on a basis of potential savings in labor. A small automatic plating machine will cost in the vicinity of $10,000. Therefore, the saving of one man in labor will pay for the machine in a few years. If a hand plating department uses four people, three racking and one plating, it is very likely that the plater can be eliminated and some time will be saved in racking, since the racks may automatically return for hand racking and unracking directly on the racks at the load-unload station. If parts are of such a size that racking is simple, so that two men rack and plate, it is quite likely that one man can do the same work with a machine, including the checking of control devices.

▸ Types of Equipment

If the decision is reached to investigate automatic machines, a choice exists between three basic types of equipment: Rotary, straight-line and return.

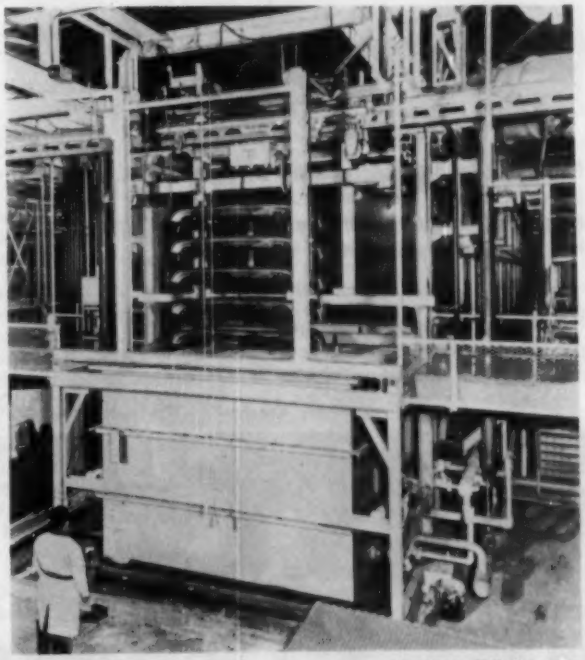
The rotary is a circular machine with tanks arranged like the spokes of a wheel and with an umbrella type mechanism to convey racks from one tank to the next, *Fig.* 4. The transfer machinery operates on a central hydraulic cylinder. It is useful where high lift and deep tanks are desirable, as for zinc plating of steel seafolding sections. In particular, it is used for plating large and heavy parts on a simple cycle.

The straight-line consists of a series of tanks in line with a mechanism to lift and carry the racks through the line, *Fig.* 5. Like the rotary it is used for large and heavy work. However, it is not restricted to narrow tanks or to a limited cycle. A carrier may transport as many as four racks at a time on a span up to 22 feet and a load of 1000 lb. The lift may be 3 to 8 feet. It is used for plating or processing of parts such as aircraft sections.

Return-type machines are the most popular since they are available for plating of small or large rack loads. The fundamental advantage of these machines is that the carriers are continuously returned to the loading station, as in the case of the rotary, *Fig.* 6.

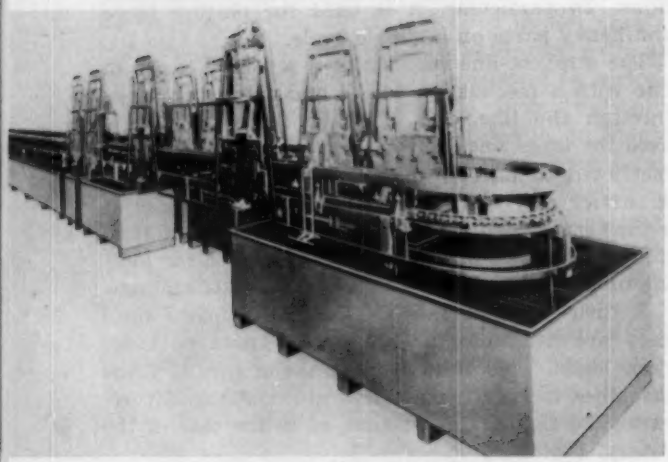
In most automatic machines, carriers are rack supporting members or arms, and the racks are detachable from the carriers. However, the rack may be fastened to the carrier, or the carrier and rack may be one and the same. This is often the case with chain-type automatics. These machines consist of a chain with the rack-carriers pivoted and fastened to the chain. A contacting shoe slides on a guiding bar that is formed to lift the racks over the edges of tanks by cam-like action. The machines are used for plating of small parts and are available as rotary and return-type machines.

Return-type automatics other than the chain-and-lift type consist of machines with transporting and lifting means. The carriers are transported horizontally by a chain drive. They are transferred from tank to tank by a lifting and lowering device or they are transferred by elevator action. On the



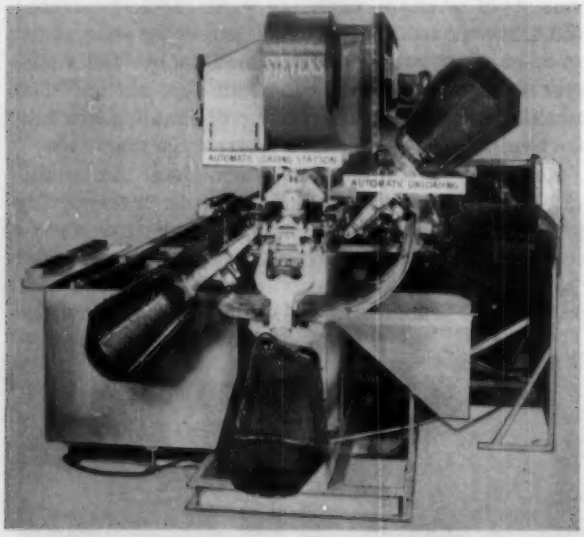
Courtesy, Udylite Corp.

Fig. 5—Straight-line automatic is particularly adaptable to those operations involving large and heavy work.



Courtesy, Hanson-Van Winkle-Munning Co.

Fig. 6—Return type automatics are widely used. Load and unload points are adjacent, providing for savings in labor. Vertical superstructures support the devices which transfer work between tanks.

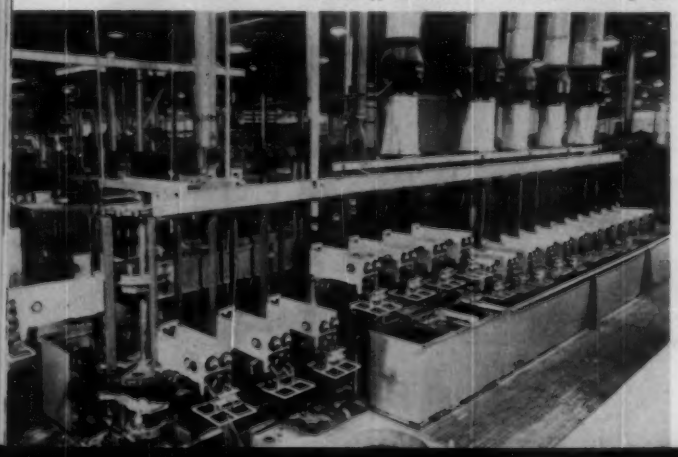


Courtesy, Frederic B. Stevens Inc.

Fig. 7—In large scale plating of small parts, rotatable barrel contains the parts during the plating operation. Parts can be automatically loaded and unloaded in this type of operation.

Fig. 8—In precision plating operation, each carrier is provided with individual current control and in this example, an agitating device.

Courtesy, Hanson-Van Winkle-Munning Co.



elevator type machine a mechanical, hydraulic or air operated mechanism lifts and lowers the carriers vertically at registered positions. The chain drive may either be a part of the elevator and move with it, or there may be fixed chain drives for moving the carriers either while in the up or the down positions.

For large volume plating of small parts, such as nuts and bolts, automatic barrel plating machines are used. These machines transfer rotatable barrel loads of work through the necessary processing steps, *Fig.* 7.

▶ Control Features

Control of the actual plating process is a function of time, temperature, current and concentration; automatic plating machines have shared in modern advances which have been made in controlling these variables in industrial applications.

Total time during which a part is immersed in a solution is controlled by the speed of the conveyor or by timing devices which cut off current and cause racks to be lifted from a tank at the proper moment. Conventional temperature controllers are used to control electric or steam heat for processing solutions.

Current is controlled on either an individual tank or rack basis. The former is normally satisfactory as each rack will draw a proportional share of the available current if anodes are properly spaced and contacts are clean. However, for precision plating, involving 5 to 10 per cent variation in plating thickness from piece to piece, it becomes necessary to control the current to each rack. This is accomplished by a rheostat and ammeter for each rack which can be mounted on the carrier arm, *Fig.* 8.

The chemical control of solutions is conventional and is more dependable in automatic installations than manual installations because of the steady load and reproducible drainage characteristics of the operation which tend to duplicate solution losses and contamination. Recent advances include use of conductivity controllers to control the flow of rinse waters based on the conductivity of the water as a measure of contamination and rinse effectiveness (See AUTOMATION, Oct. 55, Pg. 49).

Use of the automatic machine is not confined to electrolytic processes. It is adaptable to any process where the work can be handled by racks or conveyor arms. As such, machines are used also in pickling, cleaning, phosphating, dip coating, bright dipping, drying and heat treating operations. Considering the variety of successful uses of automatic plating equipment and the need for careful study and specification for each individual application, it is difficult to reach many specific conclusions concerning the equipment in a limited discussion. But fortunately it can be said that the majority of plating and solution processing requirements are of such a nature that they can be readily adapted to automatic machines purely on an economic basis.

MICRO precision switches

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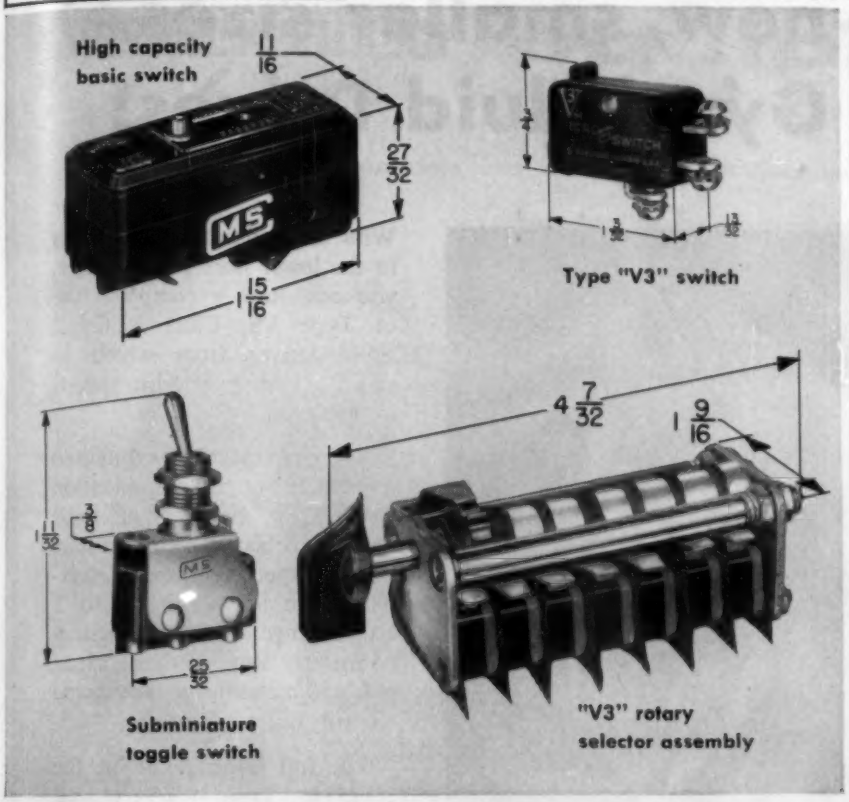

A continuous flow of Precision Switch developments anticipates designer's needs

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Type "V3" Switch. The MICRO SWITCH "V3" line switches have the highest electrical capacity for their size of any switch available. They have been developed to meet the exacting requirements of designers for an extremely small, compact switch without sacrifice of quality. Actuators are available to permit their actuation by cams, slides and other mechanical motion not in line with the switch plunger motion. (Send for catalog 74).

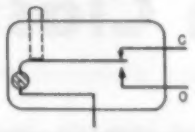
"V3" Rotary Selector Assembly. These assemblies are available with from one to eight switching units and from two to eight detent positions. Light in weight and small in size, these assemblies are well suited for use in electronic and aircraft applications. Many assemblies are available with various camming sequences. (Send for catalog 74).

High Capacity Basic Switch. This switch combines high electrical rating with high inrush capacity. The steady state current rating is 20 amperes, with inrush capacity of 75 amperes on voltages up to 460 volts a-c. These switches are especially useful for handling high inrush currents of solenoids, motors and tungsten lamps. (Send for catalog 62).

Subminiature Toggle Switch. This is one of a number of subminiature toggle switch designs developed for subminiature assemblies. The toggle switch illustrated consists of one MICRO subminiature switch riveted into the stainless steel toggle bracket. The assembly is for single-pole, double-throw service. Double-throw switches can be used "normally open" or "normally closed" by wiring to either the normally open or normally closed terminals. (Send for catalog 75).

Circuit Arrangements

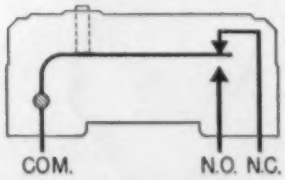
DOUBLE THROW



Type V3 Switch

This switch has a single-pole, double-throw contact arrangement. Electrical rating is: 10 amperes, 125 or 250 volts a-c; ½ ampere, 125 volts d-c; ¼ ampere, 250 volts d-c.

DOUBLE THROW

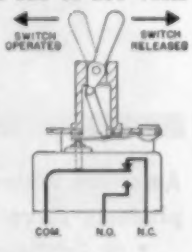


High Capacity Basic Switch

Standard switches are single-pole, double-throw. Electrical rating is: 20 amperes 125, 250 or 460 volts a-c; ½ ampere 125 volts d-c; ¼ ampere 250 volts d-c; 1 H. P. 115 volts a-c; 2 H. P. 230 volts a-c; 10 amperes 125 volts when controlling tungsten filament lamp loads on a-c circuits.

Subminiature Toggle Switch

Contact arrangement is single-pole, double-throw. Double-pole, double-throw assembly, using two subminiature switches is available. Electrical rating is: 5 amperes 125 or 250 volts a-c. The 30 volt d-c rating is, inductive—3 amperes at sea level and 2.5 amperes at 50,000 feet, resistive—4 amperes at sea level and 4 amperes at 50,000 feet, maximum inrush is 15 amperes.



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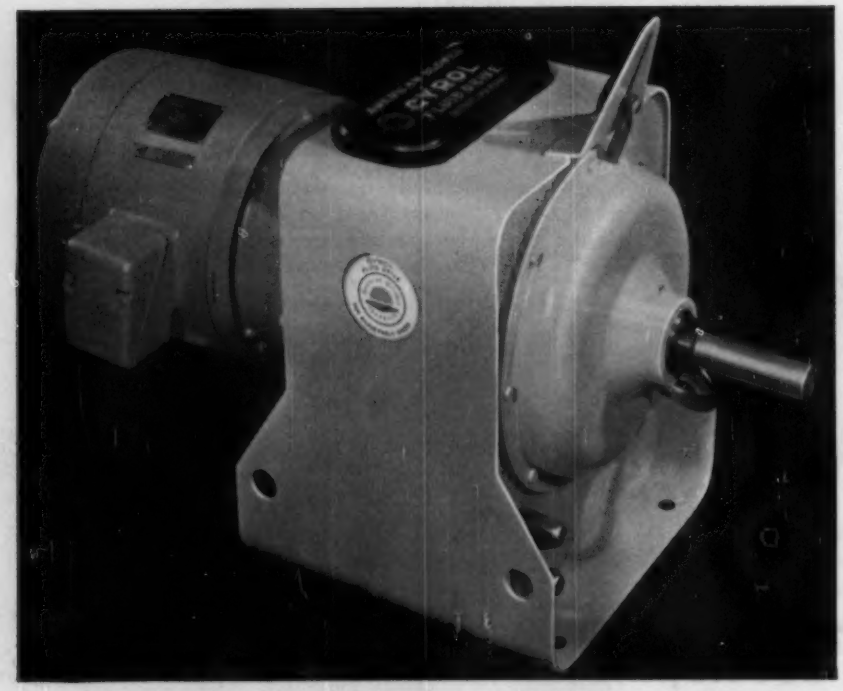

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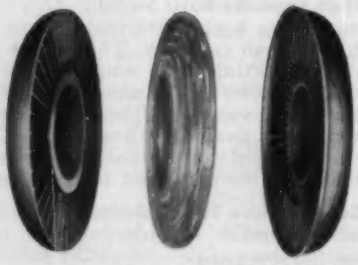

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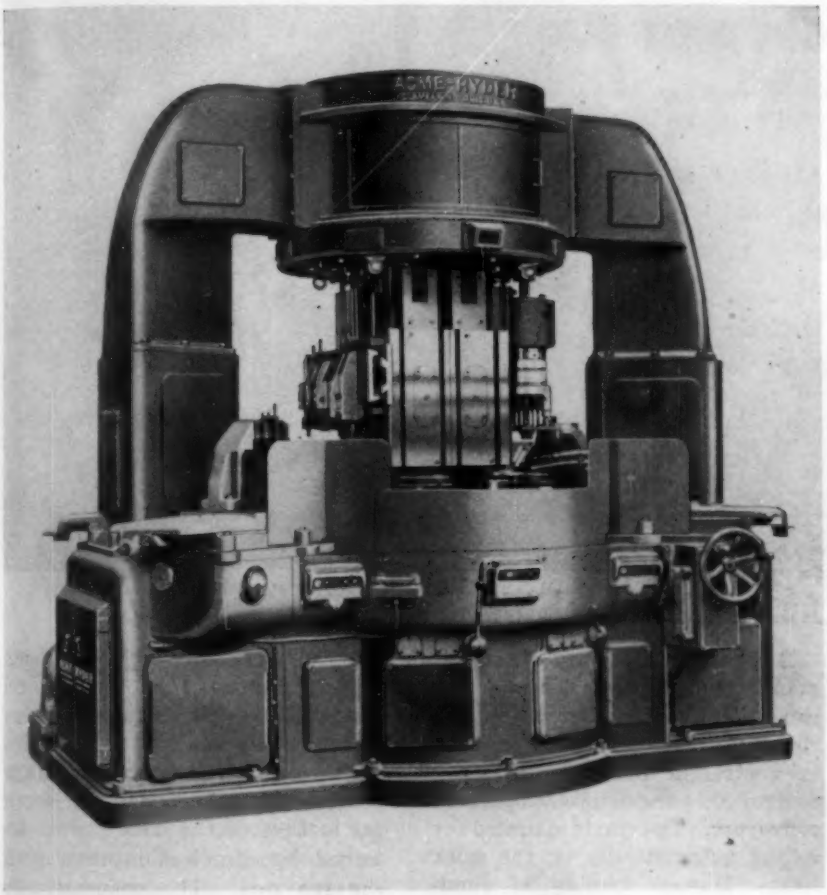
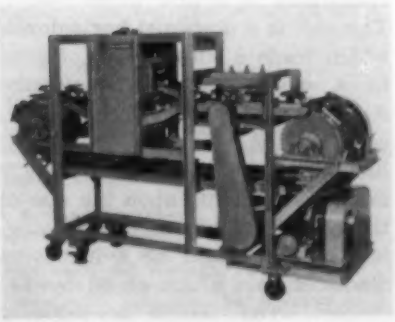


Automatic Vertical Chucking Machine

Large capacity, multiple-spindle vertical hydraulic chucking machine has eight spindles and is equipped with 14-inch capacity chucks, eight turning slides and four cross slides. In addition, four "auto cross slides" can be operated on the vertical turret at one time to provide greater tooling adaptability for production machining of large forged and cast workpieces. A six-spindle model equipped with 17-inch capacity chucks, six vertical slides and four cross slides is also available. The cross slides complement the vertical end working slides and provide flexibility and additional tooling operations previously not available in a single machining setup in these capacities. Because the independent cross slides of the unit are mounted on the lower frame and actuated from cam drums located directly beneath them, they provide maximum support for the heaviest forming cuts as well as cross facing or necking operations on the surface of the piece. Machine power is designed not only to make use of the most modern cutting tools to best advantage but also to provide an ample reserve to accommodate future tooling advancements. Standard spindle speed range is 32 to 628 rpm. Three spindle speeds are available at each spindle position with each set of pick-off gears providing satisfactory speeds for various cutting requirements. Positive indexing of the spindle carrier is by an independent indexing motor with hydraulically operated locking and clamping at completion of index. Changeover from single to double index (or vice-versa) is accomplished quickly by the removal or addition of a cam on the indexing tappet shaft. The electrohydraulic system not only provides a convenient means of actuation and control, but also enables a number of electrical, hydraulic and mechanical interlocks to be included as safety devices to protect both machine and operator. A master timing cam drum controls the completely automatic machining cycle, operating switches for the entire electrical circuit including the electrohydraulic circuits. **National Acme Co.**, 170 E. 131st St., Cleveland 8, O.

Circle 401 on Inquiry Card

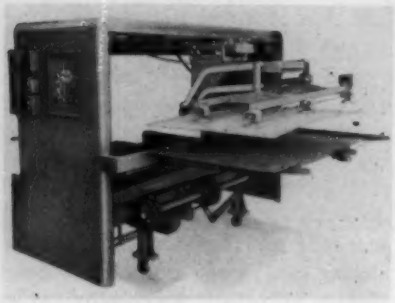


Tube Cutter and Conveyor

Automatic sawing and deburring unit with built-in conveyors for the rapid handling of tubing will handle tubing up to 1½ inches

in diameter and up to 0.050-wall thickness. Tubing is loaded into an automatic clamping fixture and then sawed in half. The saw can be constructed to cut the tubing at any required angle. A single cut delivers two identical parts from each piece of tubing fed into the unit. After sawing, conveyors elevate one-half of the tubing and lower the other half; both are then advanced for deburring. At the end of each cycle, two finished parts are delivered by the conveyor to the assembly line. The illustrated unit is used for cutting and deburring brass tubing which is 1½ inches in diameter and has a wall thickness of 0.040. The unit is set to cut the tubing at a 30-degree angle and delivers 720 completed pieces every hour, leaving no scrap. **Cooney Industries,** 17245 E. Ten Mile Rd., E. Detroit, Mich.

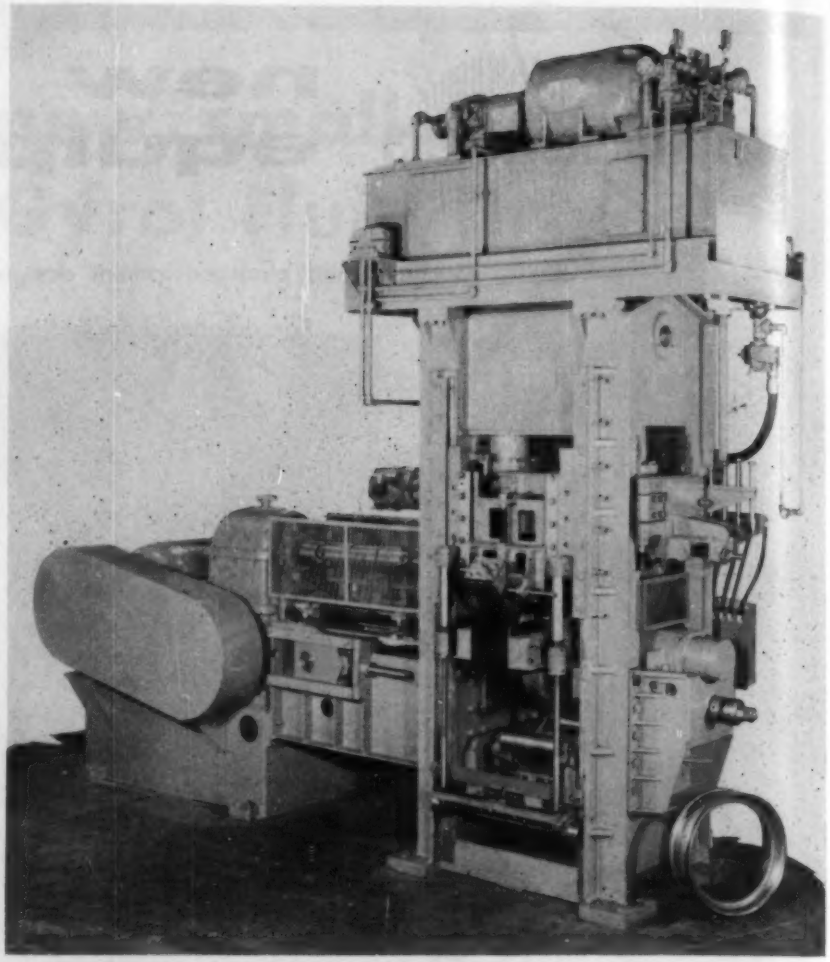
Circle 402 on Inquiry Card



Sheet Feeder

Addition to line of automatic equipment designed for feeding, pulling and positioning parts at the die press in heavy metal stamping operations is a new sheet feeder. The unit is a standard basic device which feeds a single sheet of steel to a punch press automatically. Air operated with 110v electrical controls, the machine is capable of handling up to 30 steel sheets a minute, depending upon the size of the blank. It will take sizes ranging from a blank of 8 inches in diameter to a sheet of 48 by 144 inches. The feeder is self-contained and completely movable. Its controls can be interlocked with those of the presses and with those of other models in the line. **Hamilton Automation Inc.,** Hamilton, O.

Circle 403 on Inquiry Card



Automatic Wheel Rim Roller

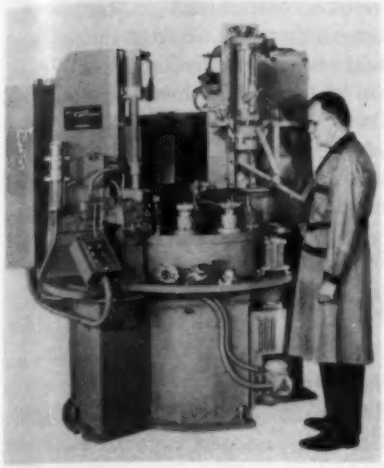
Designed for the automatic manufacture of wheel rims, new rim roller feeds and transfers the rims into and out of the machine in a straight line by electrically controlled, pneumatically operated conveyors. The rim is mounted for rolling automatically on the work rolls. Manual loading is eliminated.

Through supporting both the bottom and top work roll shafts during the rolling cycle, the new machine eliminates deflection of the roll shaft due to nonsupport. During transfer, the bottom roll retracts automatically and completely on its axis, out of the rim's path. The rim transfer devices are integral with the machine. Vertical motion of the conveyor is attained by direct connection with the top ram. The pneumatically operated side and center guides are also mounted on the upper ram. **McKay Machine Co.,** Youngstown 10, O.

Circle 404 on Inquiry Card

Assembly Machine

Feeding, positioning, assembling and ejection of completed assemblies are all done automatically by new eight-station assembly machine. The parts consist of a needle bearing, a washer and a seal which are assembled in an automotive steering gear end cover. Parts are automatically fed and positioned from indexing magazines, while the completed assembly is removed and placed on a conveyor automatically. Production rate is 720 complete assemblies per hour. A specially designed panel with plug-in aircraft type relays controls the electrical circuit. The panel is approximately one-third the size of the usual machine tool panel to fit space conservation requirements.



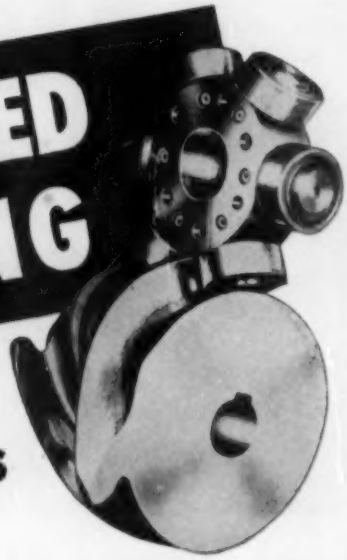
Included in the panel with the operating relays are controls which prevent assembly unless each of the component parts is correctly positioned. The index table uses both a barrel type cam and a shot bolt for accuracy, and is operated through a magnetic clutch and brake which provide a 1-second index and a 4-second dwell. Dwell time is controlled by a synchronous timer and electrical interlocks at each station. Ways are hardened and ground, and lubrication is automatic. **Omer E. Robbins Co.**, 24800 Plymouth Rd., Detroit 39, Mich.

Circle 405 on Inquiry Card

Parts Counter

Designed for automatic counting of small parts such as screws, nuts, screw machine parts, and plastic parts in predetermined quantity lots, electronic parts counter features 100 per cent guaranteed accuracy. Although the type *A* Model EC counter is designed for semiautomatic operation, since parts or pieces to be counted are placed manually into the material holding hopper, and since the carton or package the parts are being counted into must be placed by hand at the discharge chute and taken away by hand when the desired count has been completed, it can be adapted for higher degrees of automation. In the type *B* unit, the standard discharge chute is replaced with an inverted Y chute and additional control elements are added. With this modification, when a preset count has been completed, the counters are automatically reset and the flow of parts

HIGH SPEED INDEXING

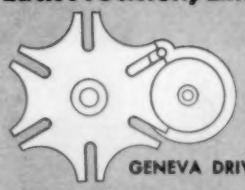


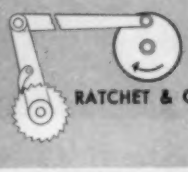
UP TO 1,000 PRECISION INDEXES PER MINUTE

with the

FERGUSON DRIVE!

Geneva Drives and Other Obsolete Indexing Devices Lack Precision, Limit Production and Wear Excessively...



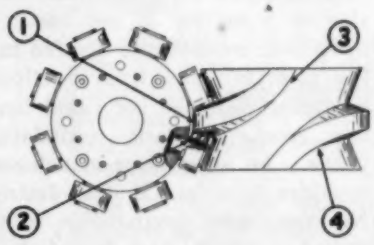


Geneva drives have abrupt acceleration characteristics. When operated at high speeds to correspond to the capacity of the rest of the machine, the tremendous shock of the sudden starts and stops soon wears out the drive and other parts of the equipment and causes vibrations and backlash that effect product quality. The plain fact is: *geneva drives limit the production of many otherwise modern machines!*

Ratchet and crank mechanisms have almost instantaneously applied accelerations. Speeds must be kept down to hold dynamic forces within limits. Even with strong auxiliary braking action, overtravel is extreme and accuracy very poor.

Of all types of indexing devices, only the Ferguson Drive has all the advantages of high speed, precision, low maintenance and design versatility!

HERE'S WHY THE FERGUSON DRIVE DOES WHAT NO OTHER INDEXING MECHANISM CAN DO . . .



1. .001" Precision; Zero Backlash

Preloaded ball bearing followers roll along tapered sides of hardened and ground cam rib. Two rollers are in contact with rib at all times. While in "rest" position, followers are engaged and locked with zero backlash by straight portion of rib. No auxiliary locking is required. *Built-in precision permits operation at maximum speed.*

2. Lower Maintenance

Ferguson Drives are rated for a minimum of 8,000 hours precision operation. When finally necessary, the Drive may be renewed for a like period by replacing standard ball bearings. *Cams have been in use for 25 years with no signs of wear!*

3. High Speed Indexing

Selection of movement and timing are independent. "Wasted" rest time can be utilized. Movement time can be reduced. *Modified trapizoid acceleration permits operation at speeds up to 1,000 indexes a minute without effecting the Drive, machine or product adversely!*

4. Reduced Vibrations

The modified trapizoid acceleration gives smooth starting and stopping, with minimum shock and vibration. In many cases where the Ferguson Drive has replaced a geneva drive, production has increased as much as 100%. *The Ferguson Drive may do this for your production machinery, too!*

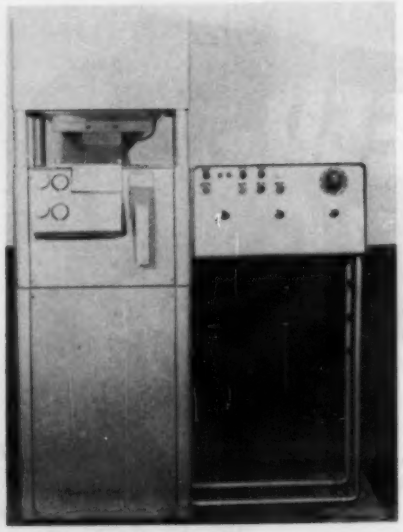
Write for Catalog of Stock and Standard Ferguson Drives

ferguson

FERGUSON MACHINE & TOOL CO., INC.

ROLLER GEAR DIVISION, DEPT. A-5 P. O. BOX 5841, ST. LOUIS 21, MO.

Circle 568 on Inquiry Card

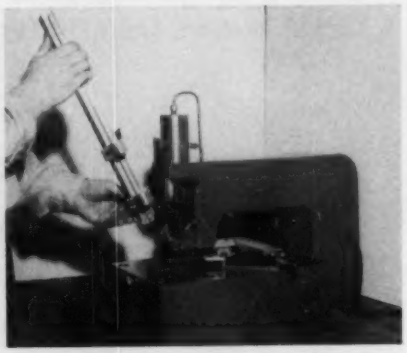


continues uninterrupted but discharge is switched alternately from one leg of the inverted Y chute to the other. For a higher degree of automation, the discharge chute may be extended to reach a belt conveyor mounted in front and below the machine. By adding additional controls to the circuit, the belt conveyor will carry empty containers to the discharge chute and remove them immediately after filling—a type *C* unit. In operation, adjustment is made to set the unit specifically for the part to be counted. This is accomplished by the installation of a marked insert by means of four screws. The insert bridges a gap between the bowl feeder and the discharge chute. When pieces to be counted pass over the insert, they are separated in single file travel and break a photobeam to register count. The number of pieces to be counted is then set by means of dials located on the front of the unit. The setting range is from 1 to 9999 pieces. An empty container is then placed at the discharge chute and the unit is actuated by pressing the start button or foot switch. Counting is performed automatically up to the preset quantity of pieces, at which time the unit stops feeding pieces into the container and indicates that the count has been completed by means of a pilot light located on the front panel. Maximum counting speed of the unit is determined by the dimension of the part being counted and packaged. **Pennsylvania Scale Co.**, Bareville, Pa.

Circle 406 on Inquiry Card

Short Run Assembly Unit

Designed to provide a flexible and reliable means of attaching electronic components to printed circuit boards where quantities involved are tens or hundreds instead of thousands, semiautomatic machine brings a degree of automation to small production runs and experimental work. This single-head Autofab unit can be changed from one component insertion to a different one in less than a minute. The entire inserting tool can be removed as a unit after a single locking lever is turned; another tool is inserted firmly into place with one locking motion. Adjustment of the tool is not disturbed. The lead crimping mechanism also can be locked or unlocked as a unit with one motion. The component feeding

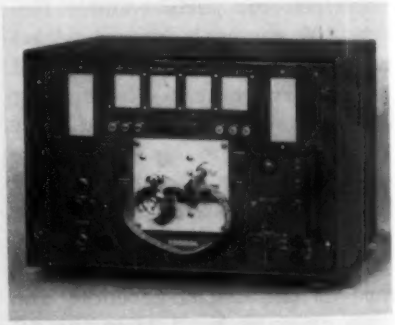


magazine clips into place. The circuit board holding fixture can be adjusted for a changed component location or a different card size in a matter of seconds. In operation, components are fed into the inserting tool from a clip-on magazine designed for rapid loading from standard automation packs. An alternative attachment provides tape feed if it is desired. No component preparation is required. Leads are trimmed to length in the machine just before insertion. The automation packs keep leads straight enough so that the Autofab requires no prestraightening operation. The operator feeds the circuit boards into the holding fixture. The insertion cycle is automatically actuated when the board hits the proper position in the fixture. The current Autofab model is designed for cylindrical components. It will mount components on center distances from 0.562 to 2 inches, and will accommodate components from 3/8 to 1 11/16 inches in length and from 1/8 to 11/16 inch in diameter. **General Mills Inc.**, Mechanical Div., 1620 Central Ave., Minneapolis 13, Minn.

Circle 407 on Inquiry Card

Automatic Tester

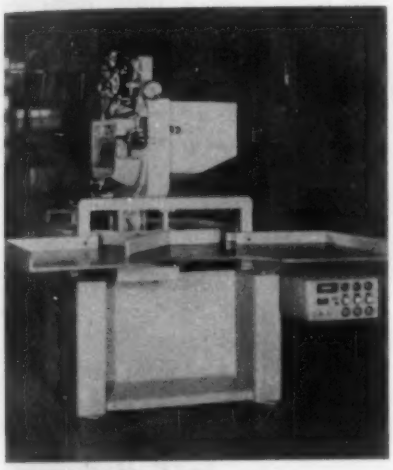
Automation of electronic equipment testing is accomplished by a new unit called the Robotester. Using a punched tape to program test points and parameters, the Robotester performs up to 120 complete circuit measurements per minute, and has a capacity of 240 test points per setup. The versatility produced by use of tape scheduling saves hours of preparation time and eliminates the cost and bulk of special program boards, black boxes or sample units. Tapes may be easily duplicated or punched on the job for multiple and remote simultaneous testing at branch factories or depots. The small size of the unit is also considered advantageous. The Robotester is an automatic resistance measuring device, selecting any two points (or point-and-ground) in prearranged sequence, measuring the resistance between them in either polarity, and passing or rejecting the reading on an individually preset tolerance. Signal lamps indicate whether the



measurement is too high, passable or too low. In the case of a reject, the Robotester stops automatically and holds until released by an operator who can note the point of rejection. Twenty-four sockets are provided for the same number of tubes or terminal boards, with up to ten test points

per socket. In operation, the tape, prepared from the schematic diagram of the system under test, first selects two points which are to be tested, in any order. No special sequence is required. The test is ordered from *A* to *B*, or from *B* to *A*, thus determining the polarity of test. The first two significant figures of the standard resistor are then selected and the number of zeros added. Tolerance (5, 10, 20 per cent) and limit (less than, ±, greater than) are then added. **Lavoie Laboratories,** Morganville, N. J.

Circle 408 on Inquiry Card



Package Filler

Exact count package filling machine receives cardboard boxes from the operator, conveys them to filling position under a spout, accurately counts out a predetermined quantity of screws or the like as they drop into the box and returns the filled box to the operator who can load a three-minute run of empty boxes into the machine. This cycle gives the operator time to apply covers to filled boxes, affix size labels, etc. Counting is accomplished at high speeds by an electronic counter, at 4 to 6 gross per minute depending on the size of the article. Machine handles other headed articles such as tacks, common and roofing nails, etc., having a size range from 0.080 to ½-in. shank diameter, up to 3½ in. long. Box size range is 1 to 4 in. both width and length, ¾ to 4 in. high. Illustrated model requires the articles to have heads. Machine features initiation of a

MERRY-GO-ROUND

straightens out electrical harness production

Automatic home washer wiring harnesses are made up of about 70 to 100 parts—wires from 6 inches to 5 feet long, dozens of terminals, contacts and connections. Formerly bench-built, production was slow, cluttered, inefficient.

We conceived this merry-go-round conveyor, where each operator adds part of the growing harness assembly as the matrix boards pass her station. Stock is carried on the overhead conveyor within arm's length at left. Result: four times the harness production with the same number of operators.

This is just one example of mechanized production engineered and built by Mechanical Handling Systems for greater efficiency and lower costs. Our experience and facilities are available to solve your production problems, too.

Call in the MHS engineer

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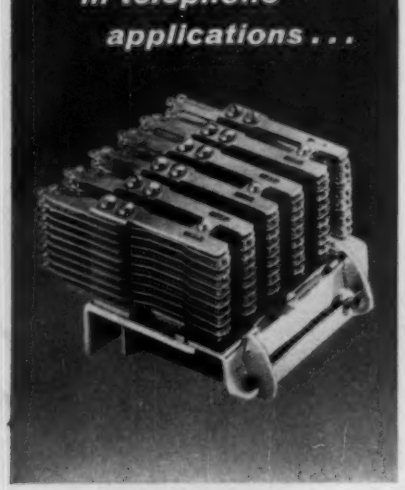
AWARD-WINNER
in telephone applications . . .



now available to you

STROMBERG-CARLSON

TYPE "B" RELAY

If reliable operation of a large number of contacts has application to your work, you should examine this remarkable relay, manufactured with extreme precision.

Our gang-type "B" relay can be furnished with combinations of A, B or C contacts with a capacity of up to 60 form A contacts. It will accommodate six stacks of spring combinations which, due to special construction, occupy an unusually small space and make the relay desirable for group mounting.

This relay has been for years distributed exclusively and in large numbers to the Independent telephone industry. Expanded production facilities enable us now to offer it to the general engineering world. Like all our relays, it is designed to operate under extreme ranges of temperature and humidity.

On request . . . If you will write or call, and state the application you'd plan to use it in, we'll be happy to send additional information, and a catalog of our entire relay line. No obligation, of course.

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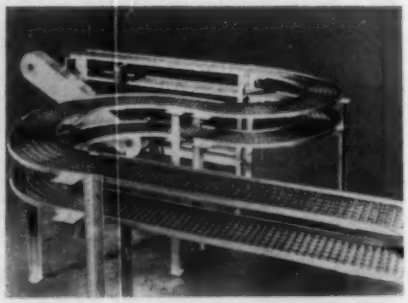
TELEPHONE INDUSTRIAL SALES

111 CARLSON ROAD, ROCHESTER 3, N. Y.

Circle 570 on Inquiry Card

slow-down, or trickle flow, just prior to reaching the final count, which makes possible exactness of count. Counting range is from 15 to 1000 articles per package. A totalizer keeps track of the number of packages filled. Machine operates on 110 v, 60 cycle, single-phase current. **Batchelder Engineering Co. Inc.**, 125 Main St., Springfield, Vt.

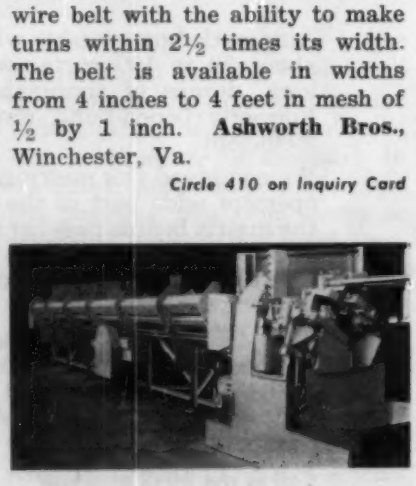
Circle 409 on Inquiry Card



Flexible Belt Conveyor

Designed to provide a flow conveyor around corners, poles and other machines, and to eliminate transfer plates or dead plate transfers, new flexible belt is recommended for use in operations involving assembly, washing, drying, sorting and packing, inspection and processing material handling. Called Omniflex, the new belt is a modification of Ashworth's flat wire belt with the ability to make turns within 2½ times its width. The belt is available in widths from 4 inches to 4 feet in mesh of ½ by 1 inch. **Ashworth Bros.**, Winchester, Va.

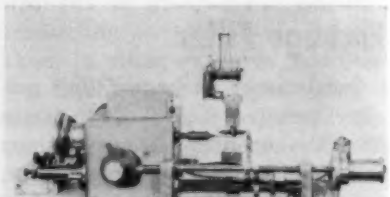
Circle 410 on Inquiry Card



Bar Feeder

Developed for use with company designed cutting-off machine, new bar feeder handles random lengths of tubing and bar stock automatically, feeding the entire stock load to the machine. Remnants of each bar or tube are automatically ejected and the end of each new bar is automatically trimmed and chamfered. The feeder has a hopper for use with lighter wall tubing. It holds approximately 100 pieces of 2¾-in. outside diameter stock or equal bulk of other sizes. An inclined table is used for bar stock of heavy tubing. Where both light wall tubing and heavy bars are used, the feeder may be equipped with both hopper and inclined table. For small diameters and light wall tubing a V-trough is used. For large stock there are rollers on which the stock rotates while cutting off, and lifting rollers for the stock while being fed through the spindle. Bar stock is fed through the spindle by the feed rolls on the machine, and as it nears the rear of the spindle, the feeder loads a new bar into the feed trough or rollers. New bar, as it automatically moves forward, acts as a pusher for the stock left in the spindle. When the old bar reaches the collet, the stock stop moves out of the way and the remnant end is ejected. **Modern Machine Tool Co.**, 2005 Losey Ave., Jackson, Mich.

Circle 411 on Inquiry Card

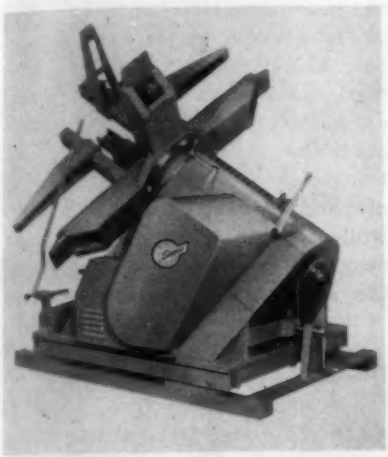


Variable Pitch Winder

Designed for long production runs, new variable pitch space winder features an electric heel and toe pedal which starts the machine and resets the cam for each new winding, permitting the operator to have full use of both hands at all times. A newly designed automatic cam return actuated by a compressed air cylinder speeds up production and reduces operator fatigue. Instant automatic brake release frees spindle, permitting operator to unfasten the start lead quickly and begin the next coil. Self-resetting automatic coun-

ter requires no handling or resetting until the turns count is changed, saving time during long production runs. Called Model 518-AM, the unit winds variable pitch single layer coils up to 3 inches long by 3 inches outside diameter. Wire sizes range from 18 to 46. One tension, one gearing setup, magnetic brake and custom built motor are supplied with the unit. **Geo. Stevens Mfg. Co. Inc.**, Pulaski Rd. at Peterson, Chicago 30, Ill.

Circle 412 on Inquiry Card



Centering Reel

Lateral adjustment for angular feeding of coil stock is provided on new centering reel. The entire reel is mounted on rails permitting lateral adjustment. This adjustment can be made easily by rotating a crank at the rear of the reel. The crank actuates a lead screw which, through a bronze nut, moves the entire reel into the proper location. The crank can be operated by hand or motorized. Four adapter arms on the centering reel are operated in unison by positive power. Arms handle the problem of variations in inside diameters of coils. Expander arms will accommodate center inside diameters from 15 to 28 in. without adapters. New method of handling large outside diameter coils provides longer continuous production runs, reduced press downtime and increased punch press productivity. Centering reel incorporates a variable speed drive so that by a simple adjustment a shorter loop can be maintained on long feed stroke

STOP...

Metal cleaning can be Automated, too!

Don't pyramid your production costs by using hand-operated metal cleaning methods. Detrex cleaning equipment can be built right into your automated line, thus eliminating slow and costly manual labor. In fact, Detrex has been building automated degreasers and washers for years.

Keep your metal cleaning processes in step with the rest of your production. Rely on Detrex quality and experience to maintain the pace. Mail the coupon for complete information on Detrex equipment or check your Sweet's Plant Engineering File.

☐ I am interested in automating my ____degreasing ____washing operation.

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NOW... Noise Free A.C. Power!

NEW CURTISS-WRIGHT DISTORTION ELIMINATING VOLTAGE REGULATOR

- Reduces typical power line distortion to less than 0.3%
- Furnishes 1.4 KVA of distortion-free power
- Electronically regulates 115 V output to ±1%
- Recovery time less than 1/50 cycle
- Provides additional 4 KVA of ±1% electromechanically regulated power
- Electromechanical time constant only 0.6 seconds
- Electromechanical regulator, unlike usual magnetic voltage stabilizer, introduces no distortion or phase shift

Here at last is the ideal solution to the disturbing problem of harmonics and low frequency noise appearing in 115 V., 60 cps power sources. In one compact package, every laboratory can now obtain *both*

1) distortion-free, regulated power when needed, and simultaneously

2) a large supply of electromechanically regulated power for applications where normal line distortion is tolerable.

In addition to its general laboratory utility, this instrument is ideally suited for preventing instability and inaccuracy in a.c. computer system nulling operations. Many other applications. 230 V. model also available. Immediate delivery. $1,689 f.o.b. Carlstadt, N. J. Write for details.

Component & Instrument Department

ELECTRONICS DIVISION
CURTISS-WRIGHT
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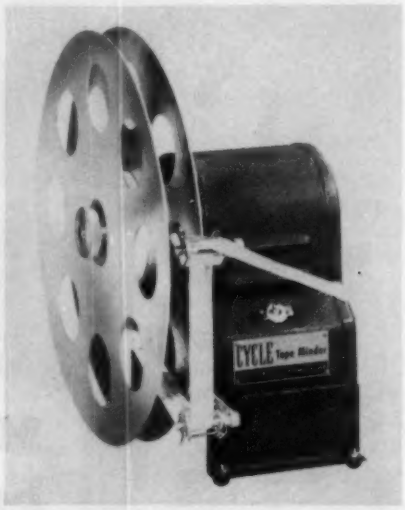
applications. Stock flow is controlled by an electrical loop control which controls the pay-off. Uncoiling of the stock is started by pressing a button. The high torque variable speed drive is reversible with automatic braking to assure rapid starting and stopping. The reel can be operated in either a clockwise or counterclockwise direction. **Sesco Inc.**, 8881 Central Ave., Detroit 4, Mich.

Circle 413 on Inquiry Card



Tape Handler

Designed for use with a variety of tape producing equipment such as teletypes, tickers, automatic typewriters, accounting and computer machines, new unit is called the Tape-Minder. Three sizes of winding reels are available and are interchangeable on the basic machine, making it useful for changing requirements. Reels are quick threading, instantly removed or replaced, and available with either large cores for retransmitting or small cores for filing. An operating arm coupled to a long interval *On-Off* switch provides delayed action winding which operates the fan cooled motor only 1/6 of the total operating time. The operating arm is built integral to a clutch release mechanism which permits the operator to spin the reels for back reference. A spring latch is also built into the clutch release which makes it possible to fix the arm in a down position to free both hands for tape inspection. The Tape-Minder is positive mechanical drive controlled by a clutch release. Reversible tape retainer guides permit flexibility in direction of feed, and an adjustable guide arm accommodates difficult positioning. Tape can be fed to the machine from above or below, right or left side, from front or back, underneath, or even at right angles to the reel. **Cycle Equipment Co.**, 420 Market St., San Francisco, Calif.

Circle 414 on Inquiry Card

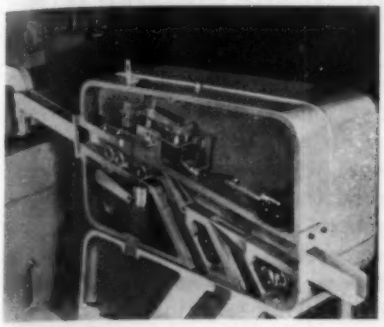
Atmosphere Generator

Automatic dew point control of the base generator gas is a feature of endothermic atmosphere generator. Compact unit combines a gas-fired endothermic generator with an automatic dew point recorder-controller. By interlocking the controller with the generator, the prepared atmosphere gas is controlled within a narrow dew point range by automatic regulation of the air/gas ratio to the reaction

tube. The result is continuous, automatic control of the prepared base gas analysis under such conditions as changing humidity and variations in analysis and pressure of the line gas. Close control of the air/gas ratio to the reaction tube minimizes the tendency to oversupply hydrocarbon which would be deposited on the catalyst, thus considerably reducing the number of periodic burnouts and maintenance. The accurate control

also makes it possible to produce uniform atmosphere gases with low dew points and completely eliminates the necessity for manual adjustments and periodic dew point checks. The automatic endothermic generator is available in sizes ranging from 750 to 5000 cu ft per hour. **Ipsen Industries Inc.**, 715 S. Main St., Rockford, Ill.

Circle 415 on Inquiry Card

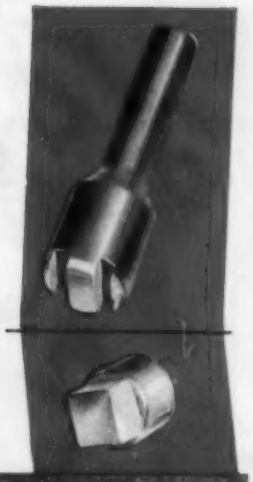


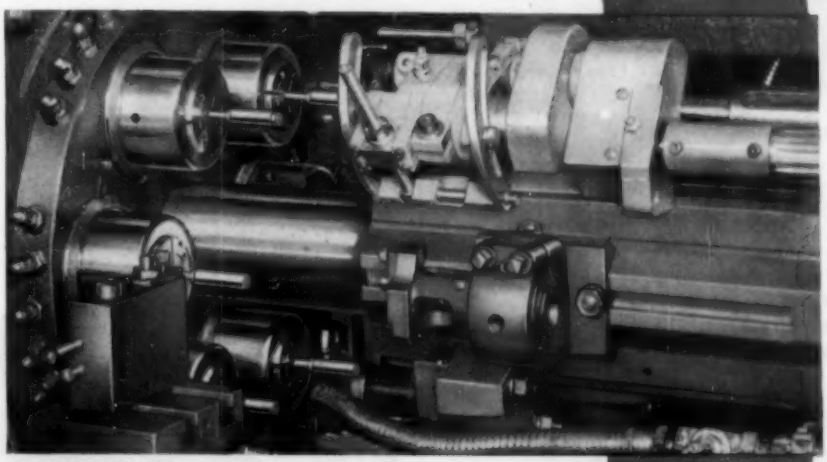
Monitoring System

An automatic, probe-type gear size monitoring system is a new addition to three-way gear classifier line. New model has a gear gaging action based on point contact of individual probes, while other models in the line use master gears. The new unit is particularly suitable where gears go directly to the classifier before passing through a washer. Probe-type model is readily adaptable to complete automation of a gear production line. Oversize, undersize and correct size gears produced on hobbers, shapers or shavers are monitored automatically, using the pitch diameter as a reference base. The new model has a three-point contact system—two lower stationary probes and one upper floating probe—that senses 100 per cent gear production from a single machine or a bank of gear producing machines. Both a visual and electrical check of production accuracy is provided within the specified tolerances of the gear pitch diameter. In operation, gears enter the classifier from the side and continue down the inclined ramp through the probe-sizing operation. Gears within specified tolerances continue through the classifier to the next operation. Any oversize or undersize gears are automatically shunted aside and collected separately

ELIMINATE SECONDARY OPERATIONS

now it's possible to mill on any standard automatic screw machine using the new patented* **turnmill**





*Patent No. 2648259

• mills on any screw machine

Merely put a Turnmill and your cutting tools on any standard automatic screw machine, and, you can mill.

• models for every size machine

There are models available for every size and make of multiple-spindled automatic screw machine used today.

• set-ups are fast and easy

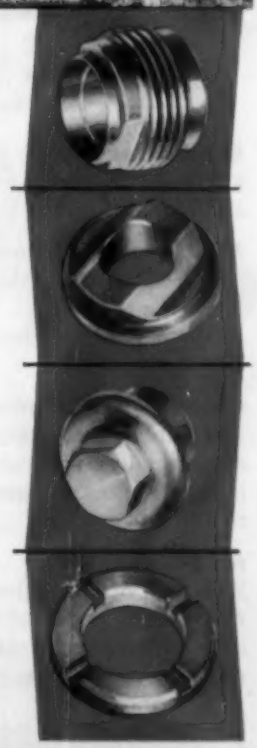
Turnmills are bolted to the end tool slides, and, are adjustable to the full capacity of any screw machine.

• it's a unique attachment

It permits you to mill any number of flats, or slots, while the part is turning in the spindle. It operates during the normal cycle of your screw machine, and it advances with the end tool slide. The number of flats or slots milled is determined by the cutter design.

• absolute concentricity assured

Absolute concentricity is assured to 0.0001" accuracy, because the cutters rotate around the stock.



Send Us Your Part Sample or Blueprint For An Estimate of the Production Rate

TURNMILL incorporated

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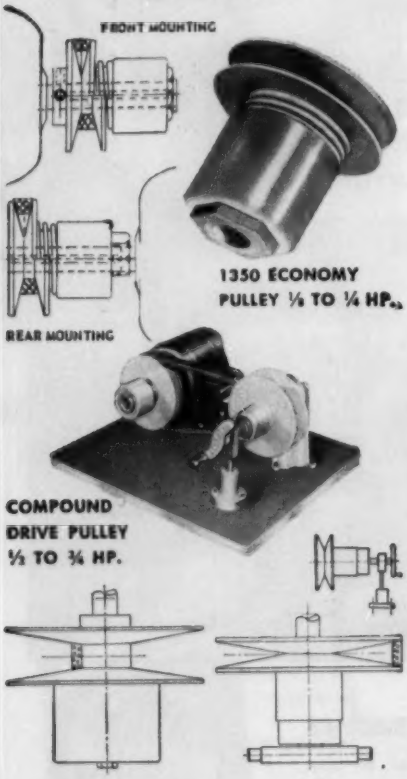
Lovejoy

Fractional Horsepower

VARIABLE SPEED PULLEYS



Economical—
low in initial cost . . . easily installed on old or new equipment.

Minimum Maintenance—
simple construction assures trouble-free operation . . . lifetime lubricated with oil-impregnated bronze bushings.

Constant Belt Alignment—
inner and outer pulley sheaves open equally to provide smooth, infinitely variable speed ratios to 8 to 1.

No Slippage—
Sure grip of belt sides delivers full traction under all load conditions...result is greater horsepower carry capacity.

Get the new 12-page Lovejoy catalog! Write today.

LOVEJOY FLEXIBLE COUPLING CO.
4951 W. Lake St., Chicago 44, Ill.

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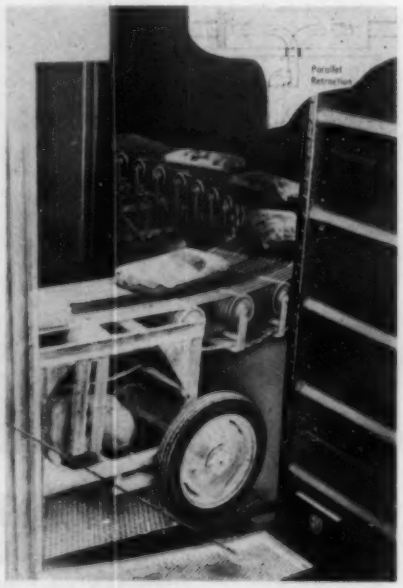
for salvage or scrap. A Geneva-type mechanism controls and times the probe movement as well as the escapement action that feeds gears to the probing station at a predetermined rate. It also locates the gear properly in relation to the upper and lower reference probes. A low speed, fractional horsepower gear motor drives the mechanism at a predetermined speed, depending upon the gear production rate. **Michigan Tool Co.,** 7171 E. McNichols Rd., Detroit 12, Mich.

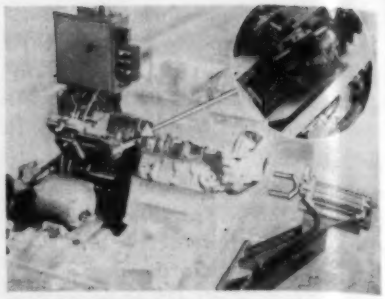
Circle 416 on Inquiry Card



Boxcar Loader

New power driven boxcar loader shuttles in and out of cars and trucks, eliminating hand trucking. It discharges bags and packages at desired elevation at the point of final stacking. The conveying arrangement is a series of steel spring belts operating over grooved rollers that are hinged together. The entire conveyor can be propelled through any curve or doorway on a radius as low as 6 ft. As loading progresses, the unit is gradually withdrawn under power, while the flow of bags or packages continues without interruption. Effective length is unlimited. Conveying capacity is 30 bags per minute, automatically transferring all the way from packing stations to the point of loading. **Power-Curve Conveyor Co.,** 2185 S. Jason St., Denver 23, Colo.

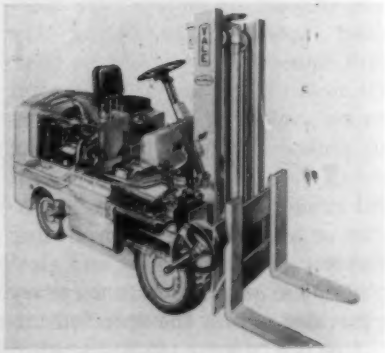
Circle 417 on Inquiry Card



Hydraulic Marking Unit

Developed for operation on automated production lines, illustrated hydraulic marking unit is installed in an automobile engine assembly line. Unit begins its cycle after receiving a signal from the master control panel and also from the workpiece in the proper station. The work cycle consists of clamping, marking, automatic indexing of numbering head (as shown in the insert), unclamping and recording engine serial number on a continuous paper tape. This cycle consumes eight seconds. After completion of a work cycle, a signal is transmitted to the master control panel and the workpiece can be moved out of its station. The marking unit is then ready to resume another cycle. With its universal mounting plate, the marking machine can be installed to operate in any desired position. **Cadillac Stamp Co.,** 17315 Ryan Rd., Detroit 12, Mich.

Circle 418 on Inquiry Card

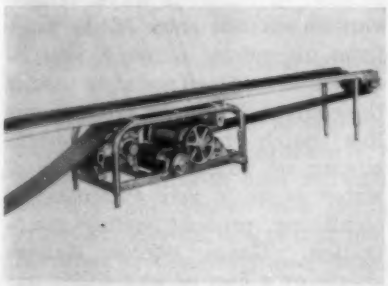


Industrial Lift Trucks

Fully automatic gear shifting feature of line of industrial lift trucks permits faster, smoother materials handling with greater operator comfort and safety. Built in capacities from 3000 to 8000 lb,

trucks transmit power by means of a torque-converter fully automatic transmission which eliminates manual shifting of gears. Since torque multiplies in varying ratios the transmission automatically puts the truck in the most suitable ratio relative to load and speed, thereby eliminating engine lugging. Possibility of transmission overheating has been eliminated by providing a large oil reservoir, running oil lines through an auxiliary radiator and applying fins to the lines. Transmission gears are in constant mesh with wide face helical gears being used for greater strength, quietness and smoother operation. Necessary oil pressure to suit requirements of torque transmission—change direction, lubricate, keep the converter unit supplied—is provided by an externally mounted pump. Whole transmission unit can be removed from the truck without disassembly. Every truck in the line is equipped with inching control for smoother and more accurate maneuvering. Slight depression of brake pedal reduces pressure on the clutch causing a partial separation of the plates and reducing power delivered to the drive wheels. **Yale & Towne Mfg. Co.**, 11000 Roosevelt Blvd., Philadelphia 15, Pa.

Circle 419 on Inquiry Card



Positive Belt Drive

Positive belt drive can be installed at any point along a conveying line. Belt slippage is eliminated since conveyor belt is lock gripped on top and bottom. Light or heavy load operations are controlled by a lever. Belt drive has forward or reverse operation. Units are available for various belt widths, with either slider bed or roller conveyor—level or incline. **Lathrop-Paulson Co.**, 2459 W. 48th St., Chicago 32, Ill.

Circle 420 on Inquiry Card

AFFILIATE OF GENERAL CERAMICS CORPORATION

Magnetic Amplifiers · INC

—announces its new

VARIABLE SPEED DRIVE

MAGNE-SPEED*

SIZE II — 3/4, 1 and 1-1/2 HP

SIZE I — 1/4, 1/3 and 1/2 HP

Stepless, instant starting, compact, 50:1 speed range, good regulation without tachometer, long life, virtually maintenance free service, low cost, fast response, reversibility, dynamic brake, local or remote control. Write for Bulletin S580-5-55.

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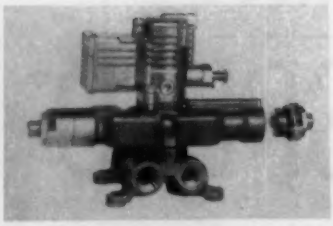
AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems

For detailed information and literature, use card page 105



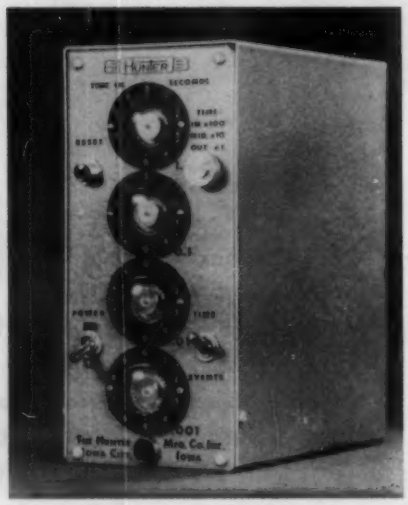
Valve Speed Controller

Designed for use on three and four-way valves with internal and external pilot supply, new speed control attachment mounts in the valve end caps. The device functions by restricting stem travel, thus regulating flow through the valve to and from the cylinder. Threaded stop screws at either end of the valve body may be adjusted to position the valve stem through a complete range of flow control, from fully restricted to fully open, in both directions. A Teflon shock pad in each adjusting screw cushions stem travel. External lock nuts secure speed adjustment settings. Speed control is self-contained within the valve and does not require separate mounting. The device is self-cleaning and provides uniform control of speeds over long periods of time because it has no needle valves or small orifices which tend to clog and change flow restriction. New speed control attachment may be installed on Valvair Speed King valves now in service, as well as on new valves. The four-way valve kit consists of new valve end caps with adjusting screws plus the special valve stem. For three-way valves, new valve end caps with adjusting screws are supplied for use with the standard valve stem. **Valvair Corp.**, 454 Morgan Ave., Akron 11, O.

Circle 421 on Inquiry Card

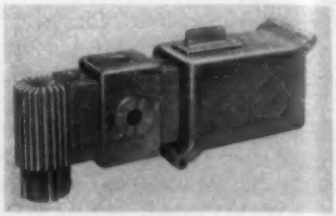
Timer-Counter

Combination timer and decade counter which weighs less than 8 lb is called the Klockounter. Unit is 4 inches wide, 9 inches high and 9 inches deep. Terminals are available so the Klockounter may be connected to measure either the time an external circuit is open or the time such a circuit is closed. By using the new "glow transfer" tube, it is possible to achieve maximum counting rate of 2000 counts



per second. Total maximum count capacity is 9999. This count can be increased by using a mechanical counter or by using additional Klockounters. For timing, the glow transfer counting circuits work in conjunction with an electric motor and photoelectric circuit to give an accurate measure of time intervals. The Klockounter will measure time intervals in units of 0.1, 0.01 or 0.001-second. **Hunter Mfg. Co.**, 930 S. Linn St., Iowa City, Iowa.

Circle 422 on Inquiry Card

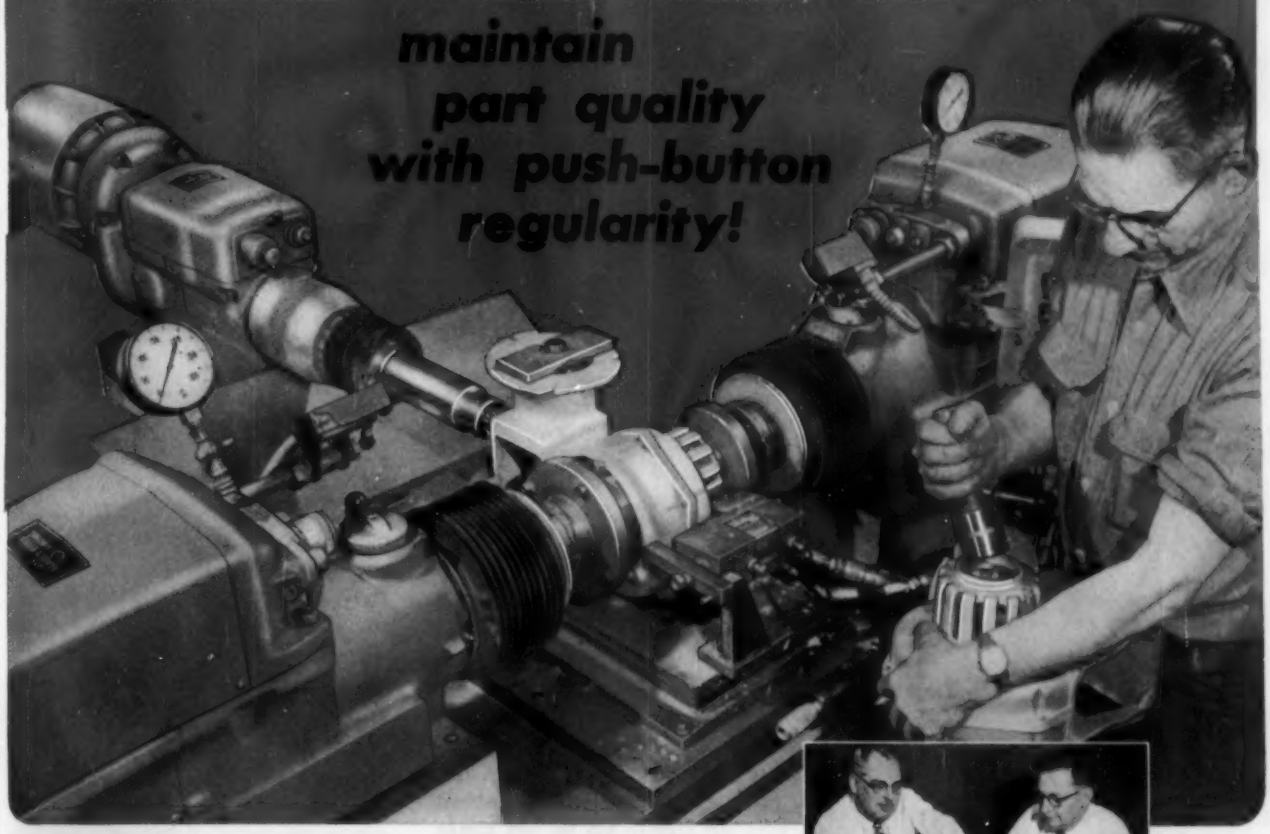


Color Sampling

New method of control in manufacturing processes through the use of wavelength absorption from a continuous flow of materials or finished products is possible by use of device called the Spectrostat. The device consists of an integrated group of unitized components which may be assembled to perform the function of absorbtion band deviation measurement in a number of different ways. Observations may be made in the range from ultraviolet through near infrared. The Spectrostat is used in the control of process factors, pipeline batch metering, automatic mixing of additives, detection of water vapor in gas, automatic replenishing, product sorting and titration. Gases, liquids, slurries, sheets or a flow of unit solids may be monitored by sensing deviations in absorbtion bands within preselected limits. The Spectrostat provides continuous sampling of any of these forms and indicates the direction of deviation beyond the set limits by a visual and/or audible warning. A 50 mv proportional output provides direct process control. Operation of the Spectrostat depends on a sensitivity to an actual change in absorbtion bands, achieved by splitting the beam between two or more detectors of different spectral sensitivity. In most operations, a change in absorbtion bands is caused by

"HARTFORD" AIR HYDRAULIC UNITS INCREASE PRODUCTION 500%...

maintain part quality with push-button regularity!



Report from the Nu-Way Corp., Rock Island, Illinois, leading manufacturer of high pressure gun-type oil burners.

Three Hartford units in a special production machine solve a critical bore alignment problem for Nu-Way. Two opposed units rough and finish bore and finish face bosses in sand cast aluminum blower housings. Through an electrically controlled sequence, rate of feed and speed is automatically regulated for roughing and finishing operations. Simultaneously a third unit at the rear is tapping a 1½" hole 90° from the two in-line bores. By roughing and finishing in one setting, perfect alignment between motor and pump bores and facings in relation to the pedestal of the burner is maintained. By changing the holding fixture, three different models of burner can be machined. On Nu-Way's model XL-2000 alone production has jumped from 14 to 80 pieces per hour!

ROBERT TURNER, Prod. Mgr., (left inset) says, "In addition to keeping rejects to a minimum, inspection is simpler and a rigid standard of quality control has been maintained."

ELMER DOYLE, V.P. in charge of production, (right inset) says, "Hartford Drill Units are doing everything we can demand in an auto-cycle operation."

GLEN LASCHANSKY, operator of the machine says, "After I set up the first casting, I never have to worry about the three drill units or the machine's operation. It will run at close tolerance as long as I press the button."

Benefit from Nu-Way's experience. Let Hartford Drill Units give you better products at lower cost through better methods.

HARTFORD *Special*

MACHINE TOOL DIVISION F-507-5
THE HARTFORD SPECIAL MACHINERY CO.
285 Homestead Avenue, Hartford 12, Conn.

☐ Have Field Engineer call.
☐ Send Application Data Sheet and descriptive Bulletin.

Name _____
Company _____
Street _____
City _____ Zone ____ State _____

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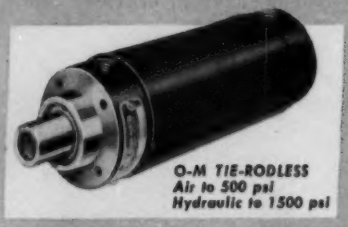
ORTMAN-MILLER Cylinders

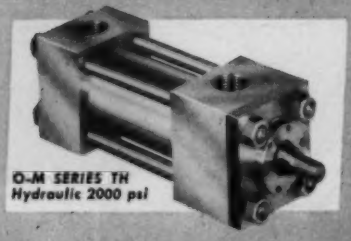
- Air and Hydraulic
- Meet JIC Standards



O-M TIE-RODLESS
Air to 500 psi
Hydraulic to 1500 psi

O-M Tie-Rodless (air-hydraulic) with compact space-saving design due to O-M Special Interlocking Mechanism, eliminates bulk . . . saves up to ⅓ installation space. Interlocking feature also makes it easy to orient ports, disassemble, inspect, clean, repair, assemble, thus reducing maintenance.

Available in complete range of sizes (1½" to 8" bores), with standard 2 to 1 or oversize rods. All steel construction with bearing bronze. Completely interchangeable parts and mounts, as described in Bulletin No. 101A.



O-M SERIES TH
Hydraulic 2000 psi

O-M Series TH—heavy duty hydraulic type rated at 2000 psi—features heavy walled seamless steel tubing and rolled steel heads accurately machined and recessed to confine the tube and prevent breathing. A multiple lip self-compensating rod gland packing, contained in a removable cartridge, facilitates replacement.

Available from 1½" to 8" bores as described in Bulletin No. 105.

Engineering Service—

Consult an Ortman-Miller representative regarding your pneumatic and hydraulic problems. His broad experience with standard and special cylinder applications is available to you without cost or obligation. Use convenient coupon for name and address of O-M representative nearest you.

Mail coupon today for Bulletins 101A and 105

ORTMAN-MILLER MACHINE CO.

25 143rd Street, Hammond, Ind.

☐ Have representative call
☐ Send Bulletins 101A and 105

Name_____ Position_____

Company_____

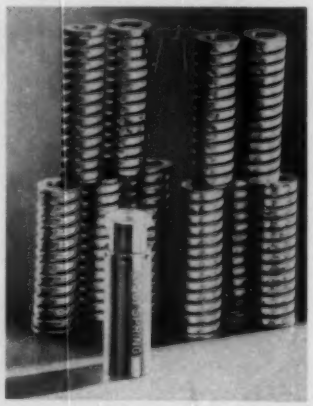
Address_____

City_____ Zone____ State_____

Circle 577 on Inquiry Card

contamination of a change in concentration of the component being controlled. The Spectrostat monitors the spectral bands of the contaminant of diluent in the production in a range from a few parts per million upward. **Kaye Development Co.**, S. Norwalk, Conn.

Circle 423 on Inquiry Card



Liquid Die Spring

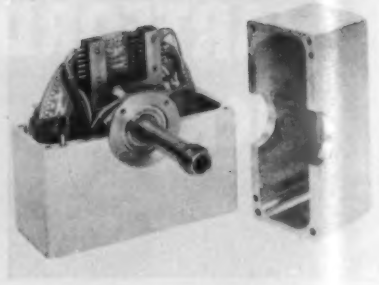
Designed to replace existing heavy duty coil springs in dies, new self-contained liquid die spring uses liquid compressibility. Through use of an internal hydraulic levering principle, the springs develop with an identical or greater stroke up to ten times the force of a standard heavy duty coil spring of the same diameter and length. The illustrated spring, ¾-inch in diameter and 2½ inches long plus mounting stud, has a 5/16-inch stroke with a 600-lb preload and an end force of 2000 lb, equaling the force, stroke and preload of ten of the same conventional size illustrated heavy duty coil springs for die use. New springs cut stamping costs by permitting simultaneous operations, thus reducing the number of single purpose dies. They reduce the size and cost of existing dies by decreasing the number of required drilled and tapped holes. **Taylor Devices Inc.**, 188 Main St., N. Tonawanda, N. Y.

Circle 424 on Inquiry Card

Coding Systems

Applicable in digitizing data in the form of shaft position, such as self-balancing potentiometers, etc., analog position coding systems can be used for direct conversion of analog data to digital form, automatic data recording, operation directly into digital computing machines, or in multichannel systems to bring together a multitude of data into compact form for easy correlation. Systems are available in two types: a nonambiguous coded type which can be read out on demand, either on the fly or at static shaft positions, and the incremental coded type which registers the instantaneous position of the shaft and each incremental change. Incremental coded type is available with driving torque as low as 0.01 oz-inch, and moment of inertia as low as 10 gram cm². **Wang Laboratories Inc.**, 37 Hurley St., Cambridge 41, Mass.

Circle 425 on Inquiry Card

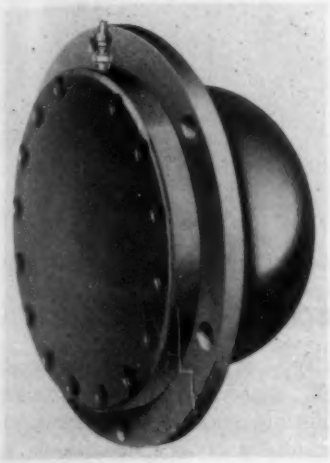


Load Cells

Designed for electrical measurement for forces and weights up to 10,000 lb in compression, miniature load cells are used where space is limited. Cells are less than 2 inches in diameter and only 2¾ inches high overall. Special cells with capacities of 2000 to 10,000 lb are available for specific applications. Not intended to replace regular larger cells of the same capacity, small size of this line was provided at a sacrifice in side load sensitivity. Cells were developed to measure thrust forces

in large steam turbines but may be used wherever space is too limited to permit use of standard cells of larger size. Calibration accuracy is within ±¼ per cent of full range at any load at 70F. Resistance across power terminals is 120 ohm. **Baldwin - Lima - Hamilton Corp.**, Philadelphia 42, Pa.

Circle 426 on Inquiry Card



Hydraulic Accumulator

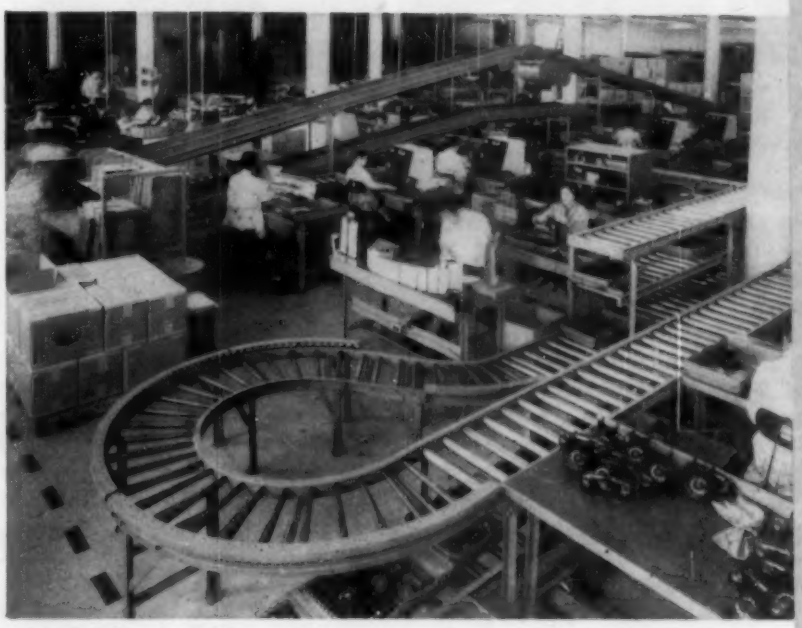
Among uses of new hydraulic motor are in traversing mechanisms, indexing turrets for high speed lathes, clamping and actuating devices of all types. By accurately storing up energy during selected time of a cycle, small, economically operated motors can replace larger electric motors and electrical controls. Accumulator features a diaphragm which is only flexed — never stretched — and which operates indefinitely without loss of precharge pressure, supplied by either nitrogen or regulator air under pressure. Flange mounted unit permits easy installation. **John S. Barnes Corp.**, Rockford, Ill.

Circle 427 on Inquiry Card

Silicon Rectifiers

Capable of handling up to several kilowatts of power, new silicon rectifiers are used as magnetic amplifiers, rotating rectifiers on the shafts of brushless generators, welders, plating lines and power packs. The new diodes have a typical forward voltage drop of only 0.7v at a current of 8 amp and at a cell temperature of 190C.

Very Few CONVEYING PROBLEMS are New to Us . . .



A typical system of Mathews gravity and power conveyers and special conveying machinery, designed to create a continuous flow of material in modern manufacturing plants in the United States and Canada.

Every day some manufacturer runs head-on into a conveying problem that's new to him . . . a handling job that he hasn't had to do before. It may be a package of unusual size or shape, or there may be unusual characteristics regarding space, temperature or weight.

Whatever the problem might be, chances are, we've done something like it, somewhere, sometime before.

That's where experience pays off, and you get the benefit of fifty years of it when you buy Mathews Conveyers.

50 YEARS OF MC MECHANIZED HANDLING

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Engineering Offices or Sales Agencies in Principal American and Canadian Cities.
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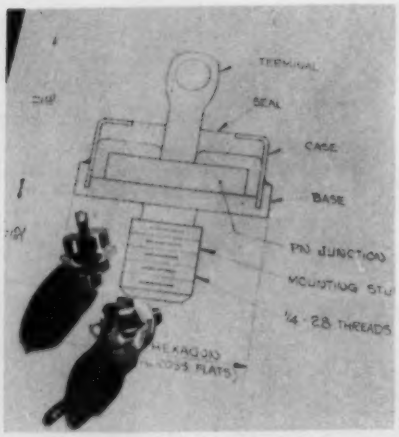
MATHEWS

Circle 578 on Inquiry Card

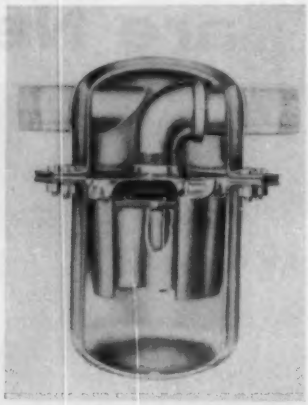


When mounted in a finned case 1 inch high and 1½ inches in diameter, the unit has a rating of 15 amp at 200v peak inverse, with natural convection cooling in a 65C ambient. Four voltage classifications are available: 50, 100, 150 and 200v. Rectifiers have a forward current rating of 8 amp with natural convection cooling at 25C. Higher current ratings up to 40 amp can be achieved with forced cooling. **Westinghouse Electric Corp., Semiconductor Dept.,** 356 Collins Ave., Pittsburgh 6, Pa.

Circle 428 on Inquiry Card

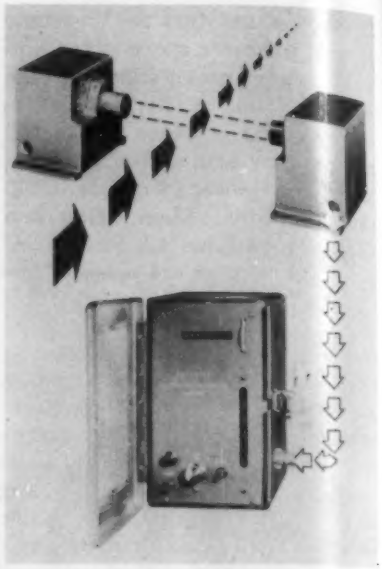
High Flow Filter

Designed for bulk handling of liquids, gases, diesel fuel, hydraulic fluids, gasoline, water, chemicals, oils, distillates and compressible fluids, high flow filter provides



efficient filtration with low pressure drop. Permanent porous bronze, cleanable filter element can be furnished for filtering out solids from 80 μ down to 6.5 μ. New high flow filter can be built to order in any size. **Arrow Tools Inc.,** 1972 S. Kostner Ave., Chicago 23, Ill.

Circle 429 on Inquiry Card



Electronic Counting

Used in counting, controlling high speed stamping, punching, tableting, molding, shearing, cutting and weighing operations, new packaged electronic counting system is made up of a counter, photocell, and light source. Model 5001 counter provides a solution to counting problems where speed requirements are in excess of the limitations of mechanical registers — 10 per second — but not great enough to warrant more extensive electronic installations. Totalized count is displayed on the decimal counting unit and the register. Total indicating capacity of the Model 5001 is 9,999,999 counts; unit is capable of 125 counts per sec. Maximum pulse-pair resolution time is 20 μ sec. A preset mechanical register can be substituted to give output switch closures from 10 to 10,000,000 counts. Contacts are rated for 115 volt ac, 2 amp., noninductive. Model 453 photocell provides a unit capable of operating directly from a 115 volt ac line. This unit, used in conjunction with the light source will operate at distances from 3 in. to 6 ft. Cathode follower output has been provided with an adjustable dc output level to permit operation of the unit at considerable distances from the counting instrument. Light source, Model 454, may be plugged directly into a 115 v. a. c. source, and uses a voltage regulator and stepdown transformer to provide regulated opera-

1 MAN ALONE OPERATES PLANTWIDE A-F ENGINEERED CONVEYING SYSTEM

Just 1 man, sitting at the control panel, shown above, automatically controls the *starting* and *stopping* of *all or part* of this A-F Engineered Completely Co-ordinated Conveying System. He also routes and switches "trains" of cases on 5 A-F Conveyor lines to 2 groups of loading docks ... Cases are automatically counted as they're being moved ... Visible and audible signals prevent traffic jams. Before you order any type of conveyor, better write us. We'll be glad to submit an estimate.

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Custom Engineered Conveying Systems
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Metal Cleaning and Processing Machines

THE ALVEY-FERGUSON CO., 172 Disney Street, CINCINNATI 9, OHIO and Azusa, Cal.

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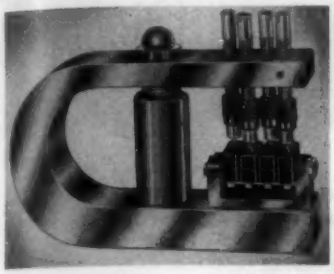
tion of the light source. **Berkeley Div., Beckman Instruments Inc.,** 2200 Wright Ave., Richmond 3, Calif.

Circle 430 on Inquiry Card



Force Gage

Designed for controlling mechanical forces at various load points, force gage is available in 11 different capacities, with only one control switch or with as many as four. Basic design centers around an alloy steel pressure beam made in the shape of a U. This beam is heat treated and designed to flex millions of cycles without losing its resiliency. To the lower leg of beam is mounted a yoke in which the switches are set. When load is applied across the center of the beam, it deflects inwardly causing the finely threaded adjustment screws in the upper half of the bar to contact the switches. On a four-switch model, each switch can be set to function at a different lead point within the range of the instrument, or all four switches can be made to function at the same load. The adjustment screws can be permanently set and sealed at the factory, or an adjustable model may be specified. Force gages can be clamped to working surfaces or bolted in place. Mounting holes are provided for this purpose. A solid steel rod is inserted between the beam so that once full capacity has been reached, the upper half of the beam bottoms against this rod. Further accidental overload then passes through the rod instead of the instrument. Available capacities are: 0 to 10 lb., 0 to 50 lb., 0 to 100 lb., 0 to 250 lb., 0 to 500 lb., 0 to 1000 lb., 0 to 2500 lb., 0 to 5000 lb., 0 to 10,000 lb., and 0 to 50,000 lb. **W. C. Dillon & Co. Inc.,** 14620 Keswick St., Van Nuys, Calif.

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Quick-As-Wink®

AIR AND HYDRAULIC

CONTROL VALVES

DESIGNED AND BUILT TO ASSURE

Double Solenoid "O-Type" Control Valve

Single Solenoid Single Plunger Control Valve

Cam Operated "O-Type" Valve

Pilot Cylinder Operated Two Position Hydraulic Valve

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Can you afford to gamble with less?

• Why build — or buy — expensive machines and then restrict their output and risk breakdowns and production tie-ups because of inferior control valves?

Positive and fast acting Quick-As-Wink valves meet the most exacting requirements. They deliver dependable precision performance month after month and year after year. Machine operators, foremen, superintendents *and machine builder trouble shooters* will tell you that there is nothing better than a Quick-As-Wink valve. REMEMBER,— your efforts to increase production and cut costs can only be as successful as the air and hydraulic valves that control the operations. Don't gamble. Play safe. Specify Quick-As-Wink valves. Get full details. Write for Bulletin No. 531, *Today!*

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LEVER OPERATED SINGLE PLUNGER VALVE ⅜" to 1½" sizes. Widely used for controlling single and double acting cylinders and as pilots for other valves.

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Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 2079 East Pershing St., Salem, Ohio

Circle 580 on Inquiry Card

Where Special Requirements Dictate Motor Construction

This peculiarly shaped motor opens and closes pipe line valves without fail in all types of weather. It is a special weather-proof torque motor designed by **Peerless Electric** in cooperation with a valve manufacturer and is equipped with an electrically operated brake. The motor shown here measures approximately 10" in diameter and 31" in length but **Peerless** can produce it in many other sizes.

The outstanding product performance attained with this motor is a result of teamwork engineering — **Peerless** — OEM cooperation. Submit your next motor problem to **Peerless.** We'll work with you to design or select the one motor that operates your product best.

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Cooney Conveyors of all types have found ready acceptance in automotive plants, foundries, forging plants, parts warehouses and many others.

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Conveyors, Material Handling Equipment or tanks engineered to suit your purpose. Send specifications or blueprints.

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Circle 582 on Inquiry Card

Berkeley news notes

NEW model 7650 MAGNETIC EPUT* METER

- *continuous-duty reliability!*
- *long component life!*
- *simplified operation, maintenance!*

BRIEF SPECIFICATIONS
COUNT CAPACITY: 5 DIGITS
TIME BASE: 0.1, 1 OR 10 SEC
ACCURACY:
± 1 EVENT, ± 50 PPM
INPUT: 0.3 MA P-P INTO 10K LOAD
PRICE (F.O.B. FACTORY): $1,495.00

Measures events occuring during precise 0.1, 1 or 10 sec time interval, displays results in digital form. Operates from photocell, magnetic pickup or any suitable transducer to measure pressure, temperature, flow, velocity, viscosity, frequency, rpm, or to count events or objects at rates to 40,000 counts per second.

Only three vacuum tubes used (35 in comparable electronic model) in rf oscillator-power supply operating at low levels. Has digital "count-down" time base for precise gating; no adjustment of time base required.

Write today for Technical Bulletin; please address Dept. V5.

Berkeley
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Circle 583 on Inquiry Card

Cylinder System

Designed for activating electrical contacts in test jigs and fixtures, new miniature pneumatic cylinder systems are also used as miniature air vises for light work-holding operations and in automatic work feeding applications. In electrical work, sleeves of ceramic or other insulating materials are easily screwed to the 8-32 threaded piston rod which is keyed to prevent its turning in the cylinder. Air hose connections are made at the side or end of cylinders. Screw plug and gasket furnished with each cylinder close air inlet not being used. Spring loading returns piston when air pressure is released. In plants which do not have air lines, miniature cylinders can be activated by a foot bellows. They are ideal for holding delicate parts when soldering, welding, brazing or assembling. Automatic work feeding of small units is also easily accomplished with the system because of its small size, flexibility and ease of mounting. **Clippard Instrument Laboratory Inc.,** 7390 Colerain Rd., Cincinnati 24, O.

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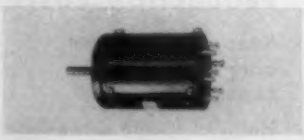

Precision Potentiometers

Producing true sine and cosine functions without eccentric gears, cams or other complicated mechanisms, precision potentiometer is designed for computer, navigational and control applications where compactness, light weight and higher operating speeds are essen-

How IH uses automatic finishing equipment

Binks installation at International Harvester

"...paid for itself 1½ times in first year of operation."

Improving product quality by improving production methods is typical of the International Harvester Company. About one year ago International sought an economical way to speed up the coating of radiator cores for its well known tractors and trucks...and to reduce the number of rejects.

K. J. Merner, Paint Engineer at International's Melrose Park, Ill., Works, called in Binks engineers to help him and his associates solve the problem. The result is a custom-designed Binks Flo-Coat machine which, says Mr. Merner, "paid for itself 1½ times in the first year of operation."

This unusual economy is obtained by:

(1) *The finishing of radiator cores at unprecedented speeds.*

(2) *Complete, uniform coating of even hard-to-get-at areas.*

(3) *Reduction of material waste to the minimum.*

(4) *Almost total elimination of rejected radiator cores.*

For every industry

Almost any mass-produced product manufactured today can be finished or coated...better, faster and more economically...with Binks automatic finishing equipment.

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Binks engineers work closely with manufacturers in the design and installation of automatic equipment that meets special requirements. Binks' long experience in this field is available to you without obligation. Just contact your nearest Binks Branch Office, or write directly to the address below:

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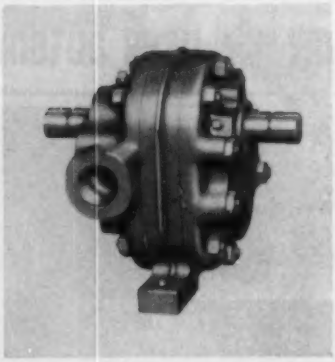
tial. Using a uniformly wound rectangular card, true sine and cosine functions are picked up by four brush contacts with accuracy and smoothness. Units may be operated at 60 rpm, and while 18,000 ohm is standard, other resistances from 4000 to 25,000 ohm are possible. At higher resistance values, angular and amplitude accuracy is 1 per cent, and power rating is 1w at 40C. **Gamewell Co.,** Newton Upper Falls 64, Mass.

Circle 433 on Inquiry Card

Hydraulic Pump-Motors

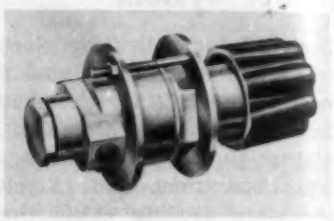
Used in materials handling, hazardous liquid dispensing, mixing operations, revolving work tables and auxiliary tools, hydraulic pump-motors work equally well operating in either direction, making it possible to use them on reversing applications. Through the use of double-end shaft extensions with overrunning clutches, units can do two jobs selectively, but not simultaneously. In many applications, pump-motors can be directly connected to the work load without the necessity of speed reducers, thus conserving space. They also eliminate the need for using oversize high speed hydraulic motors and running them at slow speeds with resulting inefficiencies. Recommended speed range on larger sizes is from 200 to 800 r.p.m. with pressures to 800 p.s.i. Hydraulic motors require from 7 to 40 g.p.m. flow and will develop up to 11.5 hp. output at maximum speed and pressure. Smaller sizes may be operated up to 1200 r.p.m. and up to 800 p.s.i. which requires a flow of 16 g. p. m. to develop up to 5 hp. **Geo. D. Roper Corp.,** Pump Div., Rockford, Ill.



Circle 434 on Inquiry Card

High Pressure Regulator

Designed for instrumentation and service system applications, new Model 101 air pressure regulator incorporates a relief valve, a sintered bronze filter and is available with either tube or pipe threaded ports. Model features wide outlet pressure adjustment ranges. Available variations include unit with 5 to 150 psi range, through three intermediate ranges to a unit with 400 to 3000 psi range. Maximum inlet pressure is 4500 psi air or gaseous nitrogen. Internal valve and filter are removable without disturbing spring and diaphragm structure. The mounting brackets are adjustable through 360 degrees. Regulator features large surface capacity of internal 5 micron filter. Internal



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Produced economically in our modern plant for:

AUTOMOTIVE, INDUSTRIAL EQUIPMENT, DOMESTIC APPLIANCE, AGRICULTURAL INDUSTRIES AND OTHERS; will boost your output at material savings.

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Tool Control Units

Reduce Production Costs on All Machines with Multiple Tooling!

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cyclemeters give you positive control of tool life

standard and special gages used for all tool lengths

REDUCE YOUR PRODUCTION COSTS

Keep your machines operating at top capacity . . .

Helps eliminate down-time for machine adjustments . . .

Eliminate trial runs . . .

Reduce your tool breakage and costly rejects . . .

Many of our Units are now in use throughout the Automotive and Metalworking Industries.

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Circle 586 on Inquiry Card

stops are provided to protect and limit abuse to intervalve structure of the regulator and to protect the unit from line failures and misapplication of pressures. **Accessory Products Co.**, 616 W. Whittier Blvd., Whittier, Calif.

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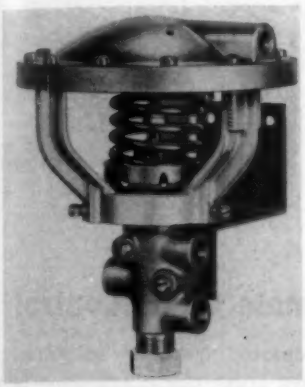
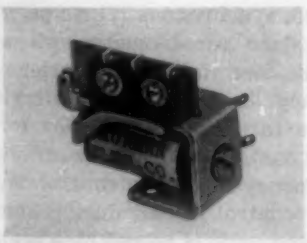


Switching Valve

Designed for use with dual pressure pneumatic control systems, pneumatically operated switching valve is a three-way model. Unit will switch automatically on a dual supply pressure change, eliminating need for separate air line from central station to accomplish switching. Use of valve for unit ventilator control reduces installation time and cost and eliminates need for second pressure-electric switch and a solenoid air valve. Three pipe connections are normally open, normally closed and common. **Johnson Service Co.**, Milwaukee 1, Wis.

Circle 436 on Inquiry Card



Telephone Relay

Designed for motor control, mobile radio and many other control circuits where there is need for a small relay to handle heavy currents of up to 5 amp, 125v ac, miniature telephone relay has a

EAGLE
CYCL-FLEX reset timer

Insures dependable operation and simplified control circuits

Designed with a sealed dial that covers the elapsed time indicator, the Cycl-Flex Timer permits direct mounting to machine panels that are exposed to oil and dust. Timer switches control four load circuits. Interlocking contacts provided without the use of auxiliary relays. Synchronous motor drive insures accurate timing.

The Cycl-Flex is one of the Eagle family of timers designed to fit into every industrial time control need. Eagle sales engineers, located in 30 principal cities, will analyze your timing applications without obligation.

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Industrial Division, Dept. A-556
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Please send Bulletin 120 containing complete data on the Cycl-Flex Reset Timer and free automation booklet, "See What Timing Can Do for You."

NAME AND TITLE

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▶ BETTER
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with
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TWINS

50 million count life — conservative rating.

1000 counts per minute — higher speeds with suitable actuation.

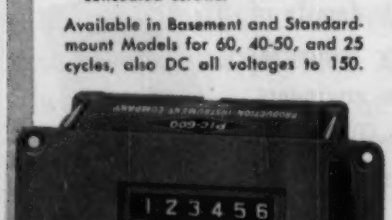
7 watts power consumption

Balanced armatures (for accurate performance on airborne equipment).

Quiet operation. No AC hum when energized.

Dust-resistant, tamper-proof housing. One-piece die-cast enclosure with close fitting cover secured with concealed screws.

Available in Basement and Standard-mount Models for 60, 40-50, and 25 cycles, also DC all voltages to 150.



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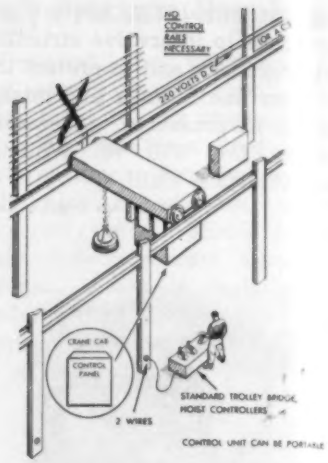
life of 100,000 operations minimum. The relay is a fast acting dc type with 100 milliwatt minimum operating power, maximum coil dissipation of 1.5w and maximum coil resistance of 6000 ohm. Special features of relay include impregnation and tropicalization, hermetic sealing, replaceable switch assembly and ac operation. As an open relay, the unit has enclosed contacts and is ideal where dust is a factor. As a hermetically sealed relay, it is completely impervious to atmospheric conditions. **Kurman Electric Co. Inc.**, 35-18 37th St., Long Island City, N. Y.

Circle 437 on Inquiry Card

Snap Action Switch

Designed for use in operations requiring extreme sensitivity, new Type-10 switch offers movement differential less than 0.0005-inch. The Type-10 is particularly adaptable to use in machine tools, appliances, vending machines, aircraft and in-plant uses. Serpentine action of the switch mechanism eliminates the problem of switch fatigue, and assures positive actuation of equipment. Since the switch has no pivot points which can cause variation in snap, it has no dead center and no flickering. The low stress design eliminates drift at the trip points. Terminals of the new switch are easily accessible and the mounting centers are 1 inch apart. Seven different types of plunger, spring and lever actuators are available. Illustrated model has a pin plunger, made of stainless steel. **Licon® Switch & Control Div., Illinois Tool Works,** 2501 N. Keeler Ave., Chicago 39, Ill.

Circle 438 on Inquiry Card

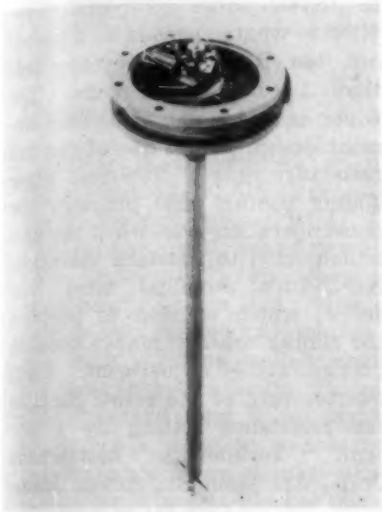


Remote Crane Control

Remote control of traveling cranes from the plant floor is provided by electronic system. Since carrier current over existing power rails is the only circuit required, installation is simple for any crane or similar device now in use or in new construction. With the new control, an operator can raise or lower the hoist (five positions), position the trolley forward or reverse (five positions), travel forward or reverse (three positions) and can energize or turn off the magnet, all from the floor. As many as eight cranes can be controlled on one power circuit by use of different carrier frequencies and one operator can operate more than one crane. By use of two control panels, a crane can be loaded by one man and then sent to the other end of its runway where another man can unload it and send it back. In operation, high speed, synchronous relays on crane and floor panel operate whenever levers are moved. Carrier frequency on each step is shifted down to a lower frequency for an *Off* control and up to a higher frequency for an *On* control. Whatever control is sent during one operating cycle is stored by a sealing-in relay until changed by another operating cycle. The small relays which operate in a few milliseconds are repeated by contactor type relays for the actual control. An emergency stop switch is provided to cut off the carrier and open the control contactors if the relay system or carrier link should fail at

any time. The floor control panel may be in a permanent location or may be placed on a cart for portability from one to another power receptacle. Femco Inc., Irwin, Pa.

Circle 439 on Inquiry Card



Level Indicator

Suitable for all dry, pulverized, fine, crushed or granular materials, new material level indicator, which is designed for the process industries, can also be adapted for use with corrosive materials, with all exposed parts built of stainless steel. Indicator may be mounted either vertically or horizontally. A maximum paddle shaft extension of 10 to 12 ft is recommended for the vertical unit; where indication is desired below this depth, the indicator should be installed horizontally. The indicator mechanism consists of a paddle wheel rotated by a 10w electric motor. When incoming material reaches the level of the paddle wheel, shaft movement is restrained. The motor, located externally, revolves on its shaft until it contacts two limit switches, which flash a signal either to the operator or directly to the feed supply. Because the motor frame must rotate through a considerable distance before it contacts the switches, false signaling caused by clumps of material striking the paddles is avoided. Even when the paddle is being held stationary by the material, electric current to the motor is not interrupted. For low level control,

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Covers:

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METER-RELAYS

For Sensitive and Accurate Control

Model 261-C Range 0/200 DC Microampers Price $33.00

RANGES:
0/20 Ua. to 0/50 A.
0/5 Mv. to 0/500 V.

The trip point is adjustable to any point on the scale arc. These meter-relays are sensitive to changes of as little as 1%. One contact is carried on moving pointer. The other is on a semi-fixed pointer. When two pointers meet contacts close and lock. Holding coil is wound directly over moving coil. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully. Three sizes of clear plastic case models, 2½, 3¾ and 4½ inches (all rectangular). Two ruggedized and sealed models, 2½ and 3½ inches (round metal cases). Contact arrangements: High Limit Single, Low Limit Single or Double (both high and low). Contact rating is 5 to 25 milliamperes D.C.

Suggested circuits for meter-relays and complete specifications including prices are covered in new 16-page Bulletin G-6, which you can get by writing Assembly Products, Inc., Chesterland 27, Ohio.

West Coast: Desert Hot Springs 27, California. Phone 4-2468. Booth 507, Design Engineering Show, Philadelphia, May 14-17.

Circle 589 on Inquiry Card

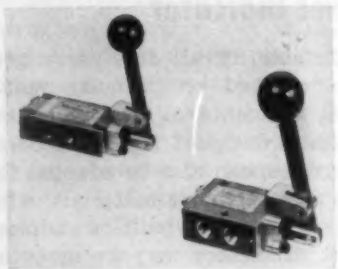
when a bin is being unloaded, the paddle wheel is held motionless, and the motor is held against the switches until the material restraining it falls away. A tension spring then returns the motor to its original position and the paddle revolves. The switches can control numerous combinations of circuits for shutting off material flow. **Fuller Co.**, Catasauqua, Pa.

Circle 440 on Inquiry Card

Trimmer Potentiometer

Precise, stable voltage adjustment for compact assemblies is provided by subminiature wire wound trimmer potentiometer. Called the RWT, the unit provides an independent linearity of ±5 per cent, standard, and a ±10 per cent standard accuracy of total resistance. Low temperature coefficient of the resistance wire contributes to the high electrical stability of the unit over a wide temperature range. Standard temperature range of the RWT is −55 to 95C. Range of standard resistance values available is from 50 to 15,000 ohms. Especially applicable where space is at a premium, ten RWT units occupy less than 1 cu inch of space. The wiper assembly and resistance element design permit use of the full resistance range. The dual wiper sliding contact also provides low noise operation even when the unit is subjected to constant vibration. A 25-turn stainless steel lead screw, which is used to position the sliding contact, makes possible precise, stable adjustment. Each quarter turn of the screw changes the resistance setting by 1 per cent. **Technology Instrument Corp.**, 531 Main St., Acton, Mass.

Circle 441 on Inquiry Card



Compact Valves

Designed for air or hydraulic control applications at working pressures up to 200 psi, new valves are available in palm button, foot lever, roller, cam or pilot-operated types, as well as illustrated hand lever type. New three and four-way operated valves feature compactness, reliability and ease of installation. Rectangular body design provides flat surfaces on all sides for easy and compact mounting. Valve body is only ¾-inch thick, 1½ inches wide and 3 13/16 inches long overall on three-way valves, 4⅝ inches long on four-way valves. Design incorporates a single sliding spool, with standard O-ring seals throughout. **Modernair Corp.**, 400 Preda St., San Leandro, Calif.

Circle 442 on Inquiry Card

FOR YEARS... PROCTOR & SCHWARTZ HAS BEEN A LEADER IN APPLYING CONTINUOUS PROCESSING TO THE TEXTILE, CHEMICAL, FOOD AND PROCESS INDUSTRIES

Automatic Conveyor Systems... Automatic Cotton Batting Systems... Pre-forming Feeds... Textile Blending Systems... Automatic Range Drying Systems... these are only a few of the successful entries made by Proctor & Schwartz into the field of automation. In planning your automatic systems and equipment, why not consult Proctor first? We have been supplying automated equipment to industry for over half a century.

PROCTOR AUTOMATION AT WORK

PROCTOR AUTOMATIC BATT MAKING SYSTEM
From bale to folded mattress batt, the Proctor system is completely automatic. From the time stock is deposited on the picker feed table until the finished batt is delivered cut and folded no labor is required. Product uniformity is assured. Engineered to specific needs.

Automatic Equipment for:
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TEXTILE FIBERS & FABRICS
and many others

Proctor

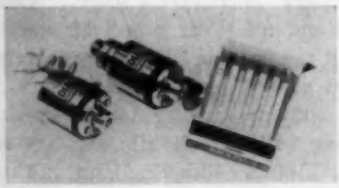
PROCTOR & SCHWARTZ, Inc.
Philadelphia 20, Penna.
Manufacturers of Textile Machinery and Industrial Drying Equipment

Circle 590 on Inquiry Card

Geared Joint

Torque is transmitted at any angle from 45 to 315 degrees by newly designed geared joint. Device features needle bearings which have increased its efficiency approximately 60 per cent. New design is also lighter and smaller in size than previous models having the same torque capacity. Primary use of geared joint is for making sharp bends in valve remote control linkages using flexible shafting or reach rods. Worker installing the unit merely connects up each end to either flexible shafts or reach rods, brackets the joint in place at one end, and then drills a spot for a set screw to keep the two halves of the joint at the proper angle. Geared joint can be used for power applications with speeds up to 500 r. p. m. **Stow Mfg. Co.**, 197 Shear St., Binghamton, N. Y.

Circle 443 on Inquiry Card



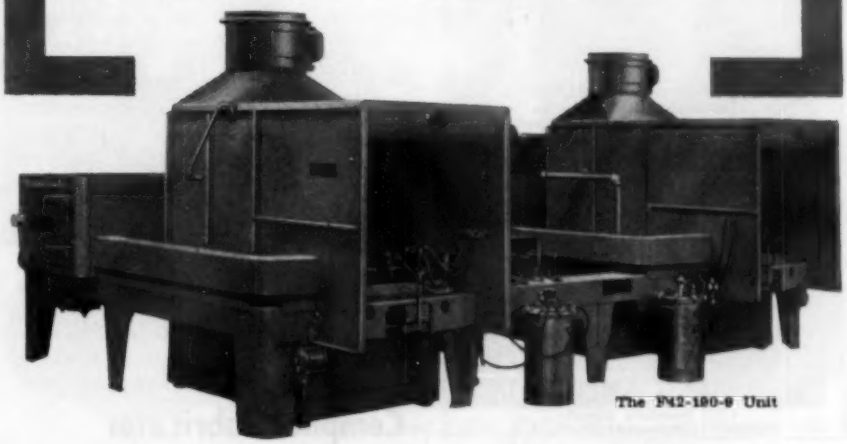
Tiny Clutches & Brakes

Possibilities for miniaturization in applications where a simple disconnect or nonchattering brake is required are provided by electromagnetic clutches and brakes. Clutches can also be used for intermittent duty in slip applications. New units weigh only 2½ oz, measure less than 1 inch in diameter and consume only 2w of power, but deliver 30 oz-inch of torque. They can be used at speeds up to 4000 rpm, and their response time ranges from 10 to 15 milli-

10,000 Individual Parts—or 10,000 Square Feet per 8 Hour Day—On a PAASCHE Automatic Airfinishing and Baking Unit

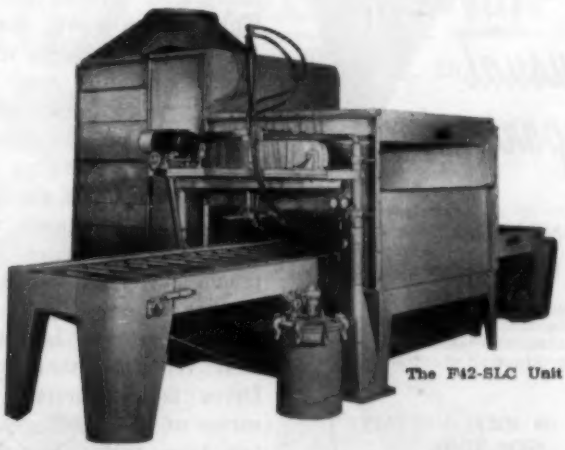
Bring your production finishing problems to Paasche's Engineers and get the benefit of more than 50 years experience in designing units that will . . .

- PACE PRODUCTION
- PRODUCE BETTER FINISHES
- REDUCE OPERATING COSTS
- REDUCE SPACE REQUIREMENTS
- REDUCE MATERIAL REQUIREMENTS
- INCREASE PRODUCTION & PROFITS



The F42-180-6 Unit

This Automatic Aircoating and Baking Unit is designed to coat and bake camera parts at 10,000 pieces per 8-hour day. A complete finishing system, contains two coating stations, water-wash booths and electrically heated oven.



The F42-SLC Unit

This Straight Line Conveyor Automatic Aircoating Unit is designed to coat wallboards, synthetic tiles, roofing materials and trays of small parts and hardware. Capacity 10,000 square feet per hour. Unit is complete with Automatic Oscillator and water wash booth.

Write for details and free survey of your finishing problems.

PAASCHE AIRBRUSH CO.

DIVISION OF CLINE ELECTRIC MANUFACTURING COMPANY

1901 Diversey Parkway, Chicago 10, Ill.

PAASCHE AIRBRUSH (CANADA) LTD.
TORONTO 6, ONTARIO

Circle 591 on Inquiry Card

New PRESET COUNTER by FREED

MODEL 2020

The Freed Model 2020 Preset Counter is designed for low cost reliable counting applications, where accuracy and maintenance-free operation is required.

Cold cathode counting and trigger tubes, with simplified circuits, are used throughout which assure years of trouble-free counting service and low-power consumption.

Model 2020 is a 4-digit single preset counter capable of controlling any operation that is repeated up to 9,999 times. Any number from 1 to 9,999 may be preset on the 4-digit selector switches. When the preset total has been reached, the counter will provide an output pulse and close contacts on a relay. These outputs may be used simultaneously or separately to stop machines, actuate control signals, or trigger additional equipment.

SPECIFICATIONS

Maximum Count: Four digits — 9,999	Pulse output 50 volts
Maximum counting rate: 600,000 counts per minute	Size: 8 x 6 x 12 inches
Input Sensitivity and Waveform: Not critical	Weight: 11 pounds
Outputs: Relay contact 10 Amperes	Power: 25 watts 105-125 volts, 50-60 cycles
	Price: $425.00

Freed also manufactures Totalizing, Preset, and Batching Counters

SEND FOR COMPLETE INFORMATION

Engineering assistance available for adapting these counters to your specific applications.

FREED TRANSFORMER CO., INC.
1705 Weirfield Street
Brooklyn (Ridgewood) 27, N. Y.

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Unusual Opportunity

FOR

INDUSTRIAL ENGINEER

Requires knowledge of scientific approach to establish methods and production standards.

IN IDEAL UPSTATE NEW YORK

Phone R. M. Jarrett collect, or send resumé to Dept. K-17

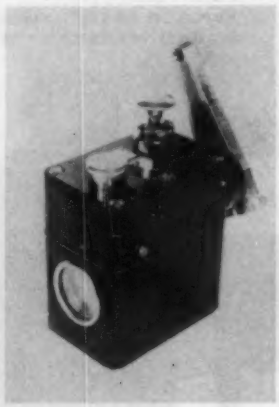
Westinghouse

ELECTRONIC TUBE DIVISION • ELMIRA, N. Y.

Circle 593 on Inquiry Card

seconds, depending upon the power input and load characteristics. Clutches and brakes are available for operation at 28 or 100v dc; other voltages can be specified on special order. Dimensions are: 15/16-inch outside diameter by 2 inches for the clutch, and 15/16-inch outside diameter by 15/16-inch for the brake. **Dial Products Co.**, 9 Ave. E, Bayonne, N. J.

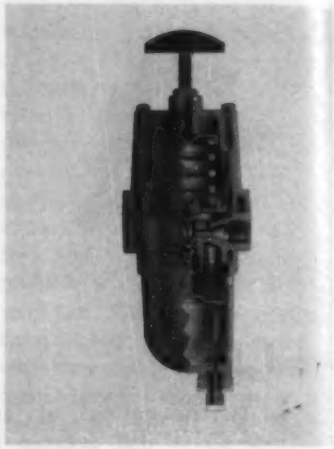
Circle 444 on Inquiry Card



Compact Lubricator

Centralized lubrication on small machines where a minimum of installation space is available is provided by compact automatic lubricator. Cyclic type lubricator, which has a newly designed, close fitting ratchet drive, will feed controlled amounts of oil to as many as 25 bearing points on a machine. Automatic unit is designed to lubricate small complex mechanisms such as are found on circular knitting machines, bench top presses, tabulating machines and testing machinery. New model is powered by machinery it lubricates. Adjustable ratchet is attached to a shaft from a drive on the machine. Drive is transmitted through a series of reduction gears to a piston type pump. Pump discharges oil at 30 psi into a distribution system of 5/32-inch tubing. Oil is transmitted through branch lines to meter units at each bearing point, where oil is filtered and measured in exact amounts. Reservoir in bottom of unit has an 80 cc capacity and the pump delivers 0.4 cc of oil per discharge. **Bijur Lubricating Corp.**, 151 W. Passaic St., Rochelle Park, N. J.

Circle 445 on Inquiry Card



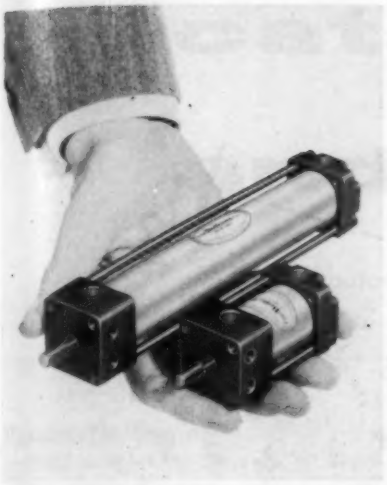
Instrument Air Regulator

Close regulation demanded for instrument air supply in pneumatic instrumentation and in other installations requiring extreme sensitivity of pressure output in small volumes of air or other gas is provided by instrument air regulator. New unit, called type 73-26, features higher air volumes, improved corrosion resistance, and a 40 μ phenolic impregnated cellulose filter. It has a minimum pressure drift from set point, gives instantaneous response to changes in flow rate. Unit provides easy adjustment to within close limits for any pressure within its output range. New regulator can be panel or bracket mounted and serviced without removing from air line. It is available with or without auxiliary pressure gage. Connections are ¼-in. pipe. Maximum input pressure is 300 p. s. i. g. Maximum output pressure is 40 p. s. i. g.; 100 p. s. i. g. with special spring. **Black, Sivalls & Bryson Inc.**, 7500 E. 12th St., Kansas City 26, Mo.

Circle 446 on Inquiry Card

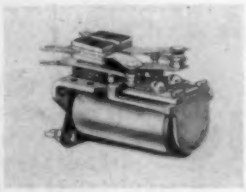
Air Cylinders

Well suited for all types of clamping, parts positioning and ejecting, as well as light duty tool and work feeding operations, line of small air cylinders is available in single and double acting models with 1, 2, 3 and 4-inch strokes. Illustration shows double-acting (air powered advance stroke, air powered retract stroke) model, 4-inch stroke, at top; the single acting (air powered advance, spring re-



turn) 1-inch stroke model is at bottom. Air cylinders are equipped for simple, universal mounting; they may be front or side mounted, front or rear flange mounted, or front pivot mounted. The 5/16-inch piston rod is threaded for easy coupling to work loads. All models develop a thrust equal to the air pressure applied. **Bellows Co., Akron 9, O.**

Circle 447 on Inquiry Card



Miniature Power Relay

Reliable switching of heavy currents up to 10 amp and operating sensitivity are combined in miniature power relay. Heavy current contacts can be furnished in combination with bifurcated contacts for switching both heavy loads and low level signal loads with the same relay. Coil and contact terminals at mounting end of the relay facilitate concealed wiring of either individually mounted or strip mounted relays. Contact combinations up to four-pole, double-throw can be furnished; hermetically sealed or dust tight enclosure models are also available. Relay operates on 60 cycle ac, any voltage up to 440; on dc at any voltage up to 230. **Magnecraft Electric Co., 3354D W. Grand Ave., Chicago 51, Ill.**

Circle 448 on Inquiry Card

BOWSER

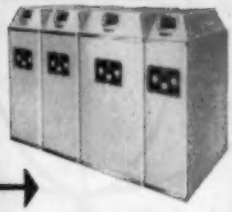
SYSTEMS SPEED LIQUIDS FROM RECEIPT TO DELIVERY

METERS & FILTERS

. . . control inventory and quality from storage or tank car through plant with meter-printed tickets for accounting of liquids handled.

PROPORTIONERS & BLENDERS

. . . eliminate costly batching with closed system compounding of liquid components. Accuracy yields uniform, controlled product.



FILLERS & PACKAGERS

. . . automatically control delivery and packaging of plant, process or end-product liquids faster at lowest cost with Bowser systems.

WRITE FOR CATALOGS

BOWSER NATIONWIDE SALES AND SERVICE

BOWSER PROGRESSIVE PROCUREMENT PLAN . . . all equipment available on lease or purchase payment program.

REGIONAL OFFICES: ATLANTA · BOSTON · CHICAGO · CLEVELAND · DALLAS · KANSAS CITY · LOS ANGELES · NEW YORK

BOWSER, INC., 1399 E. Creighton, Fort Wayne, Ind.

Circle 594 on Inquiry Card

Heads...You Win!

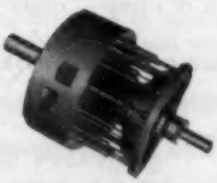
U. S. DRILL HEADS, THAT IS!

Regardless of the size of your shop, if you have high production jobs, you'll find an extraordinary reduction in tooling and manufacturing costs when you use U. S. Drill Heads.

The heads shown here, moderate in cost, are for use with automatic chucking machines and turret lathes, for drilling or tapping operations. They provide, in most cases, that a part can be completely finished in one handling.

For automatic setup.

For semi-automatic setup.

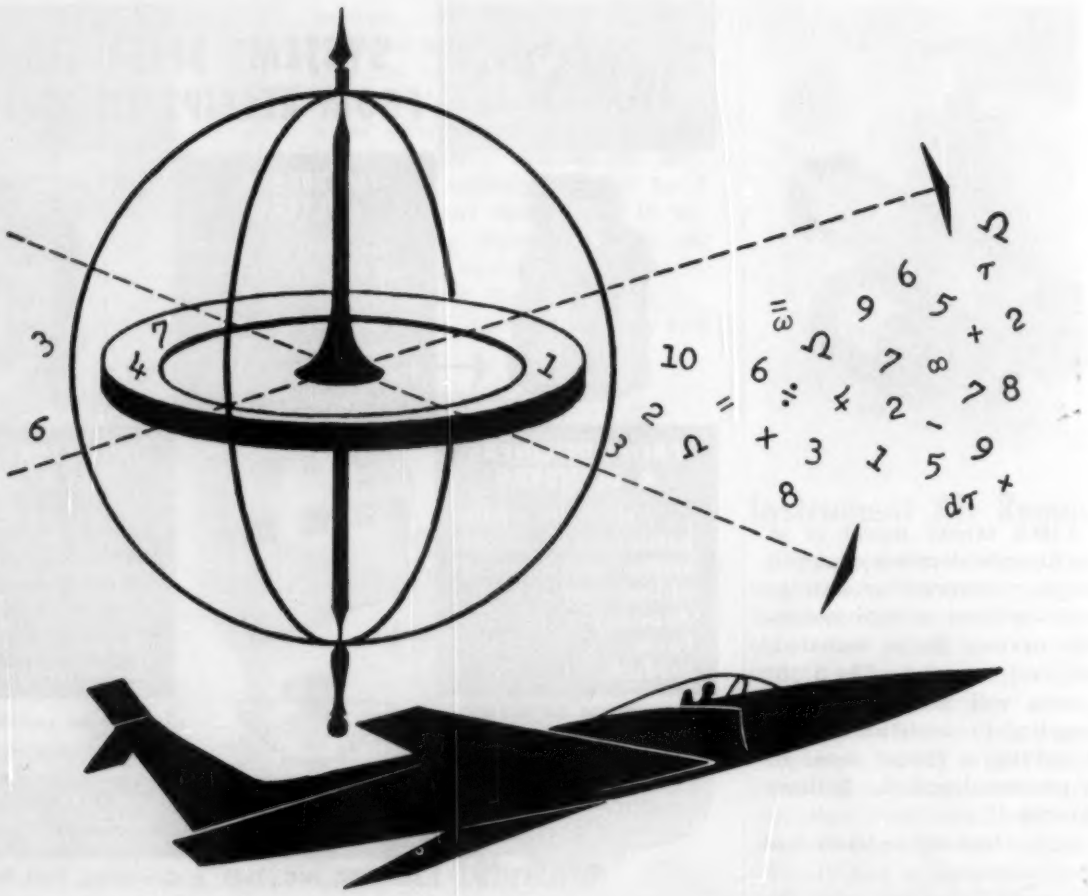


For semi-automatic setup.

Manufacturers of all types of adjustable, fixed center and individual lead screw tapping heads.

US DRILL HEAD — THE UNITED STATES DRILL HEAD COMPANY — BURNS STREET · CINCINNATI 4, OHIO

Circle 595 on Inquiry Card



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Circle 596 on Inquiry Card

catalogs and literature

Latest automation information. For copies use card page 105.

Pneumatic Gaging

Pratt & Whitney Co. Inc., W. Hartford 1, *Conn.*—24-*page catalog*—Comprised of a filter, pressure regulator, pressure gage, restriction unit and a gaging plug, Air-O-Limit comparator is discussed and illustrated in Circular No. 586. Single-station comparators, gaging plugs, snap and ring gages, multiple-station gages and attachments are illustrated and described. Application of automatic in-process gaging to centerless grinding machines, boring machines and boring transfer machine is covered. Other illustrated uses of comparators include their application on automatic honing machines, as an automatic bore gage and in the automatic gaging of outside diameters.

Circle 449 on Inquiry Card

Versatile Valves

Westinghouse Air Brake Co., Industrial Products Div., Wilmerding, Pa.—8-*page bulletin* — Designed for air, oil or water operation, Type D Pilotair valve can be used to control air flow in a line, to operate a vibrator, to clean or eject work, to operate a single-acting or double-acting cylinder, or to prevent the operation of one branch of an air circuit while there is air pressure in another branch of the same system, etc. Bulletin A4 covers the design characteristics, operating mechanisms, specifications, applications and ordering information for the Pilotair line.

Circle 450 on Inquiry Card

Instrumentation Systems

Fischer & Porter Co., 626 *Jacksonville Rd., Hatboro, Pa.* — 32-*page catalog*—Developed for the pulp and paper mill industries, line of instrumentation systems is the subject of catalog 90-130-10. Among applications of these systems are an automatic semicontinuous calcium bleach system, and a scheme for automatic preparation of soda bleach. Equipment used in control stages includes meters, indicators, recorders, totalizers and controllers. Flow diagram and description of each operation in the instrumentation system is accompanied by photographs of typical control systems installed in various paper mills.

Circle 451 on Inquiry Card

Cemented Carbides

Carboloy Dept., General Electric Co., Detroit 32, *Mich.*—66-*page handbook*—Most effective cutting speeds for carbide tools, machine tool horsepower requirements, how to determine shank size of single-point tools, carbide tool geometries, and carbide grade selection are among topics covered in handbook No. GT-310. Price and specification information on standard brazed carbide tools, tool holders, standard carbide throw-away inserts, blanks for twist drills, dies, bushings, guide rings, balls, valve seats, etc. are included.

Circle 452 on Inquiry Card

Multifunction Relays

Moore Products Co., H & Lycoming Sts., Philadelphia 24, *Pa.* — 36-*page catalog*—Numerous applications based on actual installations comprise comprehensive catalog AD68 which covers line of multifunction relays. Relays are divided into five classifications, according to their type of application: override control, multielement control, impulse control, intermittent control and characterizing. Fifty diagrams illustrate some of the most frequently used functions which can be produced by the relays. Each application page includes a sketch of the problem, the type of application, the object, the problem and the solution.

Circle 453 on Inquiry Card

Corrugated Packaging

Hinde & Dauch, Sandusky, O.—24-*page handbook*—"How To Ship More Economically in Corrugated Boxes" is the title of new booklet on corrugated packaging. Design of a corrugated box, testing, storage, shipping room layout, packing, sealing, stacking and loading are discussed. Four case histories describe specific applications of corrugated boxes and indicate how careful box design and packaging room operations have brought about savings. Illustrations indicate the proper techniques involved in each of the packaging operations.

Circle 454 on Inquiry Card

Indexing Turntables

Eisler Engineering Co., Inc., 750 *S. 13th St., Newark* 3, *N. J.*—12-*page bulletin*—Line of cams, Geneva gears, speed reducers, indexing turntables and variable speed controls is covered in booklet. Photographs illustrate single and double end drive type Geneva gears, turntables with various ranges of indexing stations, brazing machines, turntables which are adaptable for drill or power presses, television making equipment, jig boring machine and lathes. Lists of products manufactured and supplied are also included.

Circle 455 on Inquiry Card

Potentiometer Life

Helipot Corp., 916 *Meridian Ave., S. Pasadena, Calif.*—10-*page bulletin* —Discussion on the operating characteristics of a precision potentiometer during its working life is given in illustrated bulletin 573. Effects of wear on operating characteristics, such as linearity, total resistance, noise, torque and shaft play are covered. Also included are suggestions for increasing useful potentiometer life.

Circle 456 on Inquiry Card

Indicating Instruments

Illinois Testing Laboratories Inc., Chicago 10, *Ill.*—8-*page bulletin* — Pyrometers, thermometers, thermocouples, air velocity meters, dewpoint indicators, and temperature controllers are discussed and illustrated in bulletin. Both panel and portable type pyrometers are pictured and described. Specifications, operating characteristics and functions of the indicating devices are included.

Circle 457 on Inquiry Card

CATALOGS AND LITERATURE

Sensitive DC Amplifier

Weston Electrical Instrument Corp., Newark 5, N. J.—20-page booklet—Line of Inductronic® instruments, including dc amplifiers, control unit, sensitizing amplifier, product resolving system and photocell range network is discussed and illustrated in booklet.

Circle 458 on Inquiry Card

Electronic Testing

Hewlett-Packard Co., 275A Page Mill Rd., Palo Alto, Calif.—8-page bulletin—Electronic counters which handle a wide range of frequency, period and time interval measurements are discussed in bulletin. Also covered are a replacement unit which fits all standard decade counters. Oscillators, coaxial instruments, detectors, power meters, pulse generators and analyzers are described.

Circle 459 on Inquiry Card

Automatic Box Making

International Paper Box Machine Co., 315 Main St., Nashua, N. H.—8-page bulletin—New device which consists of the cages, folding elements, gluepots, hold-down parts and prefolders required for efficient folding, prefolding and untimed gluing of automatic bottom boxes is described in illustrated bulletin. Photographs illustrate the unit, called the Speed-O-Matic, folding and gluing automatic bottom, side seam glued boxes.

Circle 460 on Inquiry Card

Electronic Measuring

Marconi Instruments Ltd., 44 New St., New York 4, N. Y.—24-page handbook—"Instrumentation," a quarterly bulletin, discusses the design of electronic measuring instruments. Current issue describes development of an fm signal generator for a power meter. Information on oscillators and distortion meters is also included.

Circle 461 on Inquiry Card

Lubricating Equipment

Oil-Rite Corp., Manitowoc, Wis.—12-page bulletin—Oil cups, oiling systems, dispensers, valves, liquid level gages and chain oilers are discussed in Bulletin 100 and Catalog 10. Chain oilers which are especially suitable for intermittent operations allow any desired amount of oil to be spread and wiped evenly on the chain automatically, assuring positive controlled lubrication. Oiling systems provide automatic lubrication for machine tools, punch presses, paper machinery, baking machinery, laundry machines and textile machinery. Photographs, specifications and operating characteristics are included for all lubricating equipment.

Circle 462 on Inquiry Card

Company Product Directory

Allis-Chalmers Mfg. Co., 1205 S. 70th St., Milwaukee, Wis.—24-page handbook—Alphabetical list of company products and literature available about these products comprises handbook B6057. Literature contains operating data, construction details and technical information on the product listed. Among products covered are absorption equipment, circuit breakers, electric power control, electric motors, centrifugal pumps, starters and transformers, along with agricultural machinery and many others.

Circle 463 on Inquiry Card

Marking Machines

Noble & Westbrook Mfg. Co., E. Hartford 8, Conn.—8-page bulletin—Roll marking round or flat surfaces, precision graduating and serial numbering are performed by new Series 50 marking machines which are described and illustrated in bulletin. Numerous photographs illustrate typical applications of the machine; four standard models plus heavy duty and custom models are covered. Marking tools which are used with the machines are also discussed.

Circle 464 on Inquiry Card

Canning Instrumentation

Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Aves., Philadelphia 44, Pa.—16-page booklet — Blanching, peeling, open kettle cooking, gravity separation, container pasteurization and filling equipment are discussed in new booklet, CAN-1. Photographs and diagrams of different units used in canning process illustrate the text. Other subjects covered include exhausting, vacuum sealing, deaeration, cooling and heat exchanging.

Circle 465 on Inquiry Card

Temperature Controllers

Fenwal Inc., Ashland, Mass.—16-page booklet—Line of temperature control products ranging from a miniaturized thermostat unit to an indicating controller is discussed in booklet 500. Among the units covered are indicating controllers—electronic and mechanical and liquid filled snap-action controllers. Photographs, specifications and applications of numerous models in the line are included. Also given are a temperature conversion chart and a chart listing recommendations for protecting contacts from damage.

Circle 466 on Inquiry Card

Electrically Controlled Valves

Rivett Lathe & Grinder Inc., Brighton 35, Boston, Mass.—8-page bulletin—Hydraulic valves, solenoid controlled and subplate mounted, are the subject of bulletin 261. Cutaway drawings emphasize features of construction and operation. Different piston designs are discussed and model dimensions are given.

Circle 467 on Inquiry Card

Machining Castings

Ex-Cell-O Corp., 1200 Oakman Blvd., Detroit 32, Mich.—12-page bulletin—Step by step processing of automobile engine blocks on the automated Plymouth engine line is discussed in illustrated bulletin. Besides describing operation sequence, bulletin includes information on daily engine output, methods of handling stock and waste elements, use of natural gas instead of liquid fuel for testing the engines, and plant air filtration.

Circle 468 on Inquiry Card

Packaging Machines

Lynch Corp., Anderson, Ind. — 8-page bulletin—Line of packaging machines which automatically print, wrap, carton and overwrap butter, margarine and similar products from bulk to finished package is discussed and illustrated in bulletin. Photographs illustrate models which are used for various packaging stages; actual installations are also pictured. Chart includes information on the function, description, output, length, width, height and crated shipping weight of 42 models.

Circle 469 on Inquiry Card

Punched Card System

Burroughs Corp., Special Machines Dept., 219 Fourth Ave., New York 3, N. Y.—12-page bulletin—Electronic documentor and transcriber which prints 900 lines per minute from punched cards is described and illustrated in bulletin. Typical applications include magazine subscription fulfillment and renewal notices, billing and statement preparation, direct mail promotion and production control documents.

Circle 470 on Inquiry Card

Coil Winding Machines

Geo. Stevens Mfg. Co. Inc., Pulaski Rd. at Peterson, Chicago 30, Ill.—62-page catalog—Almost all types of coils, including continuous resistance coils, deflection yokes, bobbin, repeater, transformer, solenoid, resistor, lattice wound universal, space wound, variable pitch, toroidal, armatures and field coils, can be wound on various types of machines de-

scribed and illustrated in catalog No. 56. Photographs, specifications and operating data on 42 coil winding machines are included. Information on accessory items, along with a page of winding formulas, is also given.

Circle 471 on Inquiry Card

Magnetic Chucks

Taft-Peirce Mfg. Co., Woonsocket, R. I.—22-page booklet—Designed for use on grinders, planers, milling machines, lathes and shapers, line of magnetic chucks is discussed in Catalog No. 412. Standard lines of rectangular magnetic chucks, rotary magnetic chucks, sine angle magnetic chucks, and magnetic work drivers are described, with application photographs included. Accessory equipment covered includes control switch equipment, demagnetizers, magnetic parallels and V-blocks.

Circle 472 on Inquiry Card

Industrial Relays

Magnecraft Electric Co., 3354D W. Grand Ave., Chicago 51, Ill.—12-page bulletin—Line of relays which include short and long form telephone types for ac and dc operation, subminiature dc relays, latch-in relays, models with bifurcated contacts, miniature relays with heavy current contacts, relays with time delay, plug-in models, relays with snap action contacts and 400-cycle relays, is the subject of bulletin 55.

Circle 473 on Inquiry Card

Mass Inspection Machine

Warner & Swasey Research Corp., 34 W. 33rd St., New York 1, N. Y.—12-page bulletin—Automatic mass inspection of parts with airfoil or similar surfaces, such as turbine buckets, compressor blades, vanes, cams and gears is performed by new machine which is described in bulletin. Two models of the machine, which is called with Airfoil Probograph, are covered, with their design features, specifications and principles of operation given. Photographs and graphs illustrate the bulletin.

Circle 474 on Inquiry Card

O-Ring Sealing

Parker Appliance Co., Rubber Products Div., 17325 Euclid Ave., Cleveland 12, O.—12-page bulletin—Cross reference charts of size numbers with dimensional data for O-rings for sealing applications are given in bulletin 5701. A total of 296 standard O-ring sizes are available from the company. Also included is a chart of standard synthetic rubber compounds, special industrial compounds and standard military compounds.

Circle 475 on Inquiry Card

Furnace Equipment

American Gas Furnace Co., Elizabeth, N. J.—49-page catalog—Line of equipment for continuous production heat treating, light case carburizing, clean hardening and other processes is described in comprehensive catalog. Controlled atmosphere reciprocating hearth furnace, continuous rotary retort furnace, automatic quenching tanks, rotary gas carburizer, vertical retort gas carburizers, and surface hardening equipment are illustrated and described. Reports on actual installations and supplementary photographs are also included.

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Constant Torque Spring Motors

Neg'ator Div., Hunter Spring Co., Lansdale, Pa. — 25-page catalog — Written as a guide to the design and application of the coiled band as a constant torque motor, catalog 310Mb covers the general principles, physical and operational characteristics, typical applications and application limitations. Among suggested applications are use as an instrument antibacklash, a liquid level indicator, vending machine elevator mechanism, etc. Nine design tables present tabulated listing of available motors, giving torque output and fatigue values.

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CATALOGS AND LITERATURE

Production Machines

W. F. & John Barnes Co., 301 *S. Water St., Rockford, Ill.* — *7-page pamphlet*—Combination of successful production line layout with automatic mass machining methods to reduce automotive cylinder head costs and increase production is discussed in illustrated, fold-out pamphlet. Schematic line drawings describe operating sequence and the four machines in a line.

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Indexing Machine Chassis

Swanson Tool & Machine Products Inc., 800 *E. Eighth St., Erie, Pa.*—*6-page pamphlet* — Packaged units which provide the basic chassis for a wide range of special automatic machines are discussed in pamphlet 356-5M. Machines which are illustrated and described include four types of turret index models and straight-line indexing chassis. Photographs show chassis being used for a machine which automatically feeds, loads, pierces, lances and embosses sheet metal cups and for a machine which automatically drills, taps, reams and spot faces a cigarette lighter part.

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Magnetic Drive

Electric Machinery Mfg. Co., Minneapolis 13, *Minn.*—*4-page pamphlet*—Designed for use with an existing motor to provide adjustable speed, magnetic drive is ideal for fan and pump applications or constant torque loads. Pamphlet 4400-PRD-229 includes a cutaway drawing of the drive, selection charts, and dimensional drawing of the unit.

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Drill Press Feed

Air Control Div., Lehigh Inc., Easton, Pa.—*4-page pamphlet*—Easily attached to drill presses to make them either semi or completely automatic, new drill press feed features pneumatic power and hydraulic control. Pamphlet includes photographs which illustrate the operating cycle and operating instructions of the drill press feed, along with specifications, dimensions and a wiring diagram.

Circle 481 on Inquiry Card

Counting Devices

Presin Co., 802 *N. Fairfax Ave., Los Angeles* 46, *Calif.*—*2-page pamphlet*—Automatic cycling predetermining counters and automatic predetermining impulse counters are covered in two data sheets. Latter device is designed for electrical batch counting. Specifications, features, and photograph of both devices are included.

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Roller Conveyor Selection

Alvey-Ferguson Co., Cincinnati 9, *O.*—*6-page pamphlet*—Used in handling cartons, boxes, flat sheets, palletized loads, kegs or drums, objects with semirigid bottom requiring full width support and light objects not suitable for wheel conveying, general purpose roller conveyor is the subject of pamphlet GP. Specifications and ordering instruction for conveyors are included.

Circle 483 on Inquiry Card

Continuous Broaching

Lapointe Machine Tool Co., Hudson, Mass.—*4-page pamphlet*—Designed for mass production broaching of contours and flat surfaces, new horizontal continuous broaching machine can be equipped with hopper feed for full automation. Pamphlet includes several views of the machine which illustrate design features.

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Explosive Valves

Conax Corp., Explosive Products Div., 7811 *Sheridan Drive, Buffalo* 21, *N. Y.*—*4-page pamphlet*—Instantaneous operation is feature of lightweight valves described in pamphlet 5501-XV. Designed for use with liquids and gases, valves achieve rapid operation by firing a small completely contained explosive squib. Specifications of valves and latch pin are included.

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Pressure Ratio Indication

Norden-Ketay Corp., Instrument & Systems Div., Wiley St., Milford, Conn. — *4-page pamphlet*—Designed for use on turbo-jet engines, new pressure ratio indicating system is covered in pamphlet 361. Pressure ratio transducer and indicator units are discussed and illustrated; specifications are also given.

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Reloading Sheet Feeder

Dexter Folder Co., Pearl River, N. Y.—*6-page pamphlet*—Continuous reloading metal sheet feeder which automatically separates and picks up metal sheets from a pile and advances them to the registering or feeding point of a press, coater, slitter, etc., is illustrated and described in pamphlet. List of machines which are automatically fed by the metal sheet feeder is included, along with photographs showing the operating cycle of the machine.

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Temperature Control

Photoswitch Div., Electronics Corp. of America, 77 *Broadway, Cambridge* 42, *Mass.*—*4-page pamphlet*—Flexibility in the fast and accurate measurement and automatic control of high temperatures is provided by photoelectric pyrometer Type P2T, described in pamphlet PT556. Descriptive data, dimensions and specifications of pyrometer are included.

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Pressure Exchange Pump

Manton-Gaulin Mfg. Co. Inc., 44 *Garden St., Everett* 49, *Mass.*—*2-page pamphlet* — Designed for pumping abrasive and corrosive muds, slurries and solutions, hydraulic pressure exchange pump is the subject of pamphlet HPX-55. Details and operating principles of the pump whose design eliminates plungers and packing are included.

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Midget Solenoid Valve

Automatic Switch Co., 391 *Lakeside Ave., Orange, N. J.*—*2-page pamphlet* —Applications and development of midget packless three-way solenoid valve are discussed in illustrated pamphlet. Pressure ratings, flow conditions and explosion proof approval information are given. Also covered are standard voltages, power consumption, special features and list prices.

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Air Control Valves

Airmatic Valve Inc., 7317 *Associate Ave., Cleveland* 9, *O.*—*4-page pamphlet* — Application information and description of 17 types of air control valves and accessories is included in pamphlet. In-line two way, three-way, and four-way types are among those covered; accessories include pressure regulators, strainers and small bore clamping cylinders.

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Threading & Chucking Machines

James Coulter Machine Co., 650 *Railroad Ave., Bridgeport* 5, *Conn.*—*4-page pamphlet*—Advantages of hob threading machine, automatic threading lathe, thread milling machine and single spindle chucking machine are given in illustrated pamphlet. Diversification of tooling arrangements possible with machines is also illustrated.

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422	452	482	512	542	572	602	632	662
423	453	483	513	543	573	603	633	663
424	454	484	514	544	574	604	634	664
425	455	485	515	545	575	605	635	665
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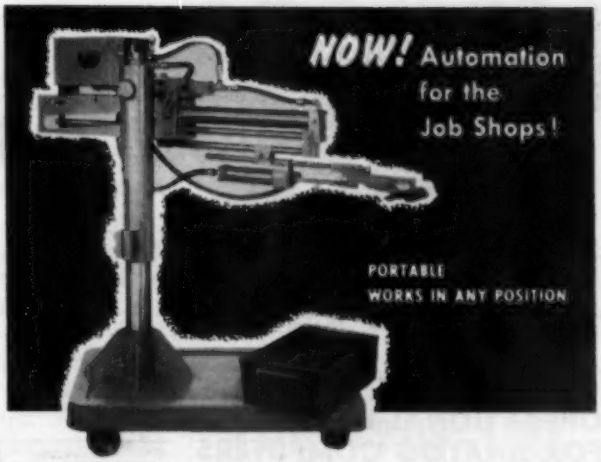

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AUTOMATION **abstracts**

OPERATIONAL EQUATIONS FOR ANALOG COMPUTERS

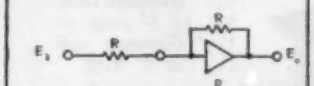
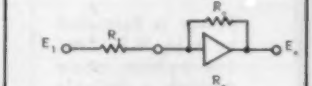
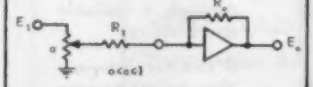
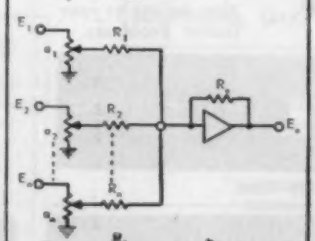
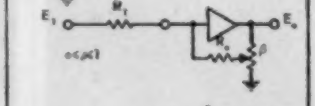
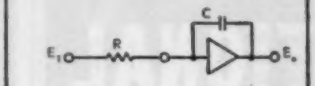
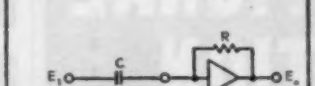
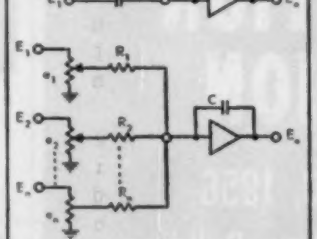
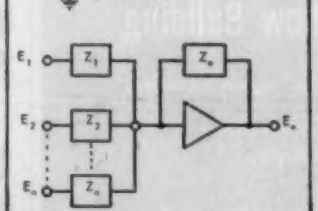
By HUGO M. MARTINEZ
Berkeley Div.
Beckman Instruments Inc.

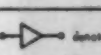
OPERATIONAL EQUATION of a circuit may be defined as an equation which relates the output to the input in terms of the mathematical operation performed by the circuit on the input. The output can be dimensionally different from the input, but nevertheless an operation is performed which transforms one into the other in a definite manner. The short circuit transfer impedance of a circuit (input voltage divided by the output current when the output terminals are shorted) is an example of an operator which transforms a voltage (the input) to a current (the output). There are many such examples in electrical theory, and all have been devised with the object of simplifying analysis and synthesis of electrical circuits. The purpose here is to formulate a similar operator theory for electronic analog circuits. It will be seen that this results in a replacement of conventional diagrams by a symbolic notation that is both easy to use and to interpret.

Computer Operations and Elements

Electronic computers are characterized by their ability to perform certain mathematical operations electronically. Whereas addition and subtraction are the basic operations of digital computers, analog computers can perform these and a variety of others such as integration, multiplication, differentiation, etc., in their repertoire of basic operations. Also just as integration and multiplica-

TABLE 1

OPERATION	COMPUTER CIRCUIT	VOLTAGE RELATION	OPERATIONAL EQUATION
1. Sign inversion		$E_o = -E_1$	$E_o = (-1)(1)E_1$
2. Multiplication by a constant and sign inversion		$E_o = -\frac{R}{R_1}E_1$	$E_o = (-R_o)(1/R_1)E_1$
3. Multiplication by a constant and sign inversion	 $0<\alpha<1$	$E_o = -\alpha\frac{R}{R_1}E_1$	$E_o = (-R_o)(1/R_1)(\alpha)E_1$
4. Addition, multiplication by a constant, and sign inversion		$E_o = -(\alpha_1\frac{R}{R_1}E_1 + \alpha_2\frac{R}{R_2}E_2 + \dots + \alpha_n\frac{R}{R_n}E_n)$	$E_o = (-R_o S)((1/R_1)(\alpha_1)E_1, (1/R_2)(\alpha_2)E_2, \dots, (1/R_n)(\alpha_n)E_n)$
5. Division by a constant and sign inversion	 $\alpha<\beta<1$	$E_o = -\frac{R}{\beta R_1}E_1$	$E_o = (-R_o/\beta)(1/R_1)E_1$
6. Integration and sign inversion.		$E_o = -\frac{1}{RC}\int_0^t E_1 dt + E_o(0)$	$E_o = (-1/CP)(1/R)E_1 + E_o(0)$
7. Differentiation and sign inversion		$E_o = -RC\frac{dE_1}{dt}$	$E_o = (-R)(C_0)E_1$
8. Summation, integration, and sign inversion.		$E_o = -\frac{1}{C_0}\int(\alpha_1\frac{E_1}{R_1} + \alpha_2\frac{E_2}{R_2} + \dots + \alpha_n\frac{E_n}{R_n})dt + E_o(0)$	$E_o = (-S/C_0)((1/R_1)(\alpha_1)E_1, (1/R_2)(\alpha_2)E_2, \dots, (1/R_n)(\alpha_n)E_n)$
9. Generalized Sum		$E_o = -Z_o(\frac{E_1}{Z_1} + \frac{E_2}{Z_2} + \dots + \frac{E_n}{Z_n}) + E_o(0)$ where Z_1 = short circuit transfer impedance	$E_o = (-Z_o S)((Z_1)E_1, (Z_2)E_2, \dots, (Z_n)E_n)$

1. The symbol  denotes a high gain D. C. amplifier.
2. The coefficient settings of the potentiometers are measured with respect to ground.
3. ALL voltages are measured with respect to ground.
4. Capacitor and resistor values are usually in microfarads and megohm units respectively.
5. Symbol S means "sum of" and p is the differential operator d/dt.
6. It is assumed potentiometer loading is included in the coefficient terms.

tion are composite operations in digital computers, electronic analog computers perform composite operations by combining several or all of the basic ones. This is the underlying principle of their use, and rules may be established to find the necessary combination for solving a given problem.

It is convenient to classify the basic operations of an analog computer into linear and nonlinear. The linear operations are sign inversion, multiplication by a constant, addition, and integration and differentiation with respect to time. The nonlinear operations are multiplication, and function generation. All these operations are performed on voltages which are either constant or varying with time, and which normally lie between plus and minus 100 volts in magnitude.

Linear Operations

Computing elements used for linear operations are resistors, potentiometers, capacitors, and high gain dc amplifiers. Combinations of these yield specific voltage operators as shown by TABLE 1. These voltage operators transform the input voltages to output voltages in accordance with the voltage relations shown. To develop the operational equations for these circuits, it is convenient to think of them as composites of the basic elements, each of which has its own operator symbol. As an example, we may consider circuit 3 of TABLE 1 to be composed of three distinct elements.

Here the potentiometer has the transfer function (a) which operates on the input voltage E_1 to yield a voltage $E_2 = aE_1$; the input resistor has the transfer function $(1/R_1)$ which operates on E_2 to yield the current I; and finally, the high gain dc amplifier operates on this current I with the transfer function $(-R_0)$ to give the output voltage $E_0 = -R_0I$. This last equation can be written in operational form as $E_0 = (-R_0)I = (-R_0)(1/R_1)\ E_2 = (-R_0)(1/R_1)\ (a)\ E_1$, which shows that the output voltage E_0 of the computer circuit is the result of operating on the input voltage E_1 successively with the operators (a), $(/R_1)$ and $(-R_0)$. It is important to note here, as elsewhere, the order of the operations since they are noncommutative; i.e., $(-R_0)\ (1/R_1)\ (a)E_1$ is not the same as $(1/R_1)\ (-R_0)\ (a)E_1$ or any other remaining possible permutation of the operators.

The equation $E_0 = (-R_0)\ (1/R_1)\ (a)E_1$ is the operational form of the normal type of equation $E_0 = -a(R_0/R_1)\ E_1$ and can be used symbolically to represent circuit 3 of TABLE 1. Since we may assign equivalent operators to other basic elements, it is clear that any other computer circuit may be represented in a similar manner by an operational equation. TABLE 2 shows the various computing elements together with their corresponding operator expressions.

It will be noticed that some of these are voltage to current converters, or current to voltage converters. A dc amplifier with a feedback impedance Z_0 accepts a current I and converts it to a voltage $(-Z_0)I$. An input impedance to a dc amplifier accepts a voltage E and converts it to a current $(1/Z_i)E$. Connecting computing elements together to form a computing circuit may, therefore, be considered equivalent to connecting a series of converters together to yield the desired overall conversion or transformation. Also, it is evident that in order to obtain a valid conversion, say a voltage to voltage, we can either use a voltage to voltage converting element or else a voltage to current converter followed by a current to voltage element. This immediately establishes the proper sequence in which operators may be arranged and hence the necessary rules of the operator algebra.

Nonlinear Operations

Use of multipliers and arbitrary function generators extends the field of application of analog computers to the solution of nonlinear problems. Multipliers accept two voltages E_1 and E_2 to give their product $E_0 = -.01\,E_1E_2$. This product is also sometimes positive, but it will here be considered negative. In operator form this can be written $E_0 = (-.01\,M)\ [E_1, E_2]$

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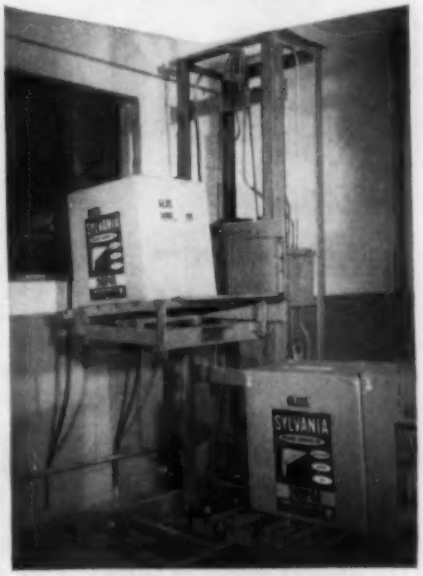

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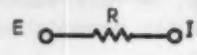
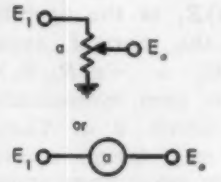
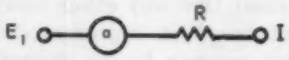
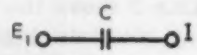
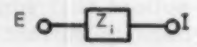
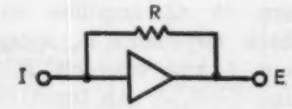
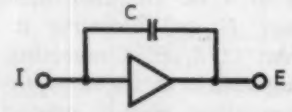
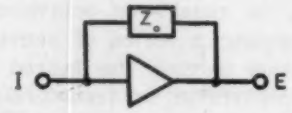
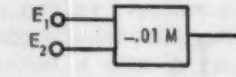
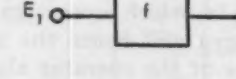
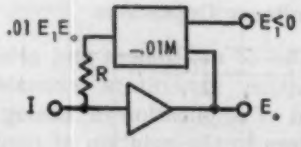
TABLE 2

COMPUTING ELEMENT	OUTPUT-INPUT RELATION	OPERATOR SYMBOL
A. Linear		
1. 	$I = E/R = (1/R)E$	$(1/R)$
2. 	$E_o = aE_1$ $0 < a \leq 1$	(a)
3. 	$I = a/R \cdot E_1$	$(a)(1/R)$ or (a/R)
4. 	$I = C\,dE_1/dt$	(Cp)
5. 	$I = (1/Z_i)E$	$(1/Z_i)$
6. 	$E = -RI$	$(-R)$
7. 	$E = -\frac{1}{C}\int I\,dt$	$(-1/Cp)$
8. 	$E = -Z_o I$	$(-Z_o)$
B. Non-linear		
1. 	$E_o = -.01\,E_1E_2$	$(-.01\,M)$
2. 	$E_o = f(E_1)$	(f)
3. 	$E_o = \frac{-100R}{\lvert E_1 \rvert} \cdot I$ $E_1 < 0$	$(-100\,R/\lvert E_1 \rvert)$
4.	$f(E_o) = -RI$	$(f)^{-1}$

where M stands for multiplier and the parenthetical operator $(-.01M)$ operates on the quantities E_1 and E_2 simultaneously. Function generators accept a voltage E_1 to give a function $f(E_1)$, such as cos E_1, E_1^2, etc. Symbolically, this operation can be written as cos $E_1 = (f)E_1$, $E_1^2 = (f)E_1$, etc., where f is the function generator operator.

As shown in TABLE 2, other nonlinear operators may be made up by placing a nonlinear element in the feedback path of a dc amplifier. In this manner a large class of inverse operations may be performed such as division, root extraction, antilogs, inverse trigonometric functions, etc.

Conclusion

Computing circuits can be replaced by symbolic equations if appropriate notation is used. It should be observed, however, that this symbolic method is just another way of doing the same thing, but with emphasis placed on the mathematical approach. In some cases where the electronic analog computer is used for direct simulation it is advantageous to draw circuit diagrams in order to indicate visually the correspondence between computer components and those of the system under study. However, even here, if the components of the system are interpreted as being operational in nature (servo components and their transfer functions, etc.) the operational notation can be used.

Among some of the advantages to be gained by using operational equations is that they provide a condensed record of the computer setup since no figures need be drawn except to qualify special symbols. Thus, any circuit schematic can be translated to operational form for economy of storage, and, since the operational equations can be easily written out with a typewriter or by hand, economy of effort in correspondence or in the preparation of publications is achieved. A great deal of time is wasted in making neat figures, work which can be avoided with the use of equations that convey the same meaning.

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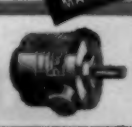

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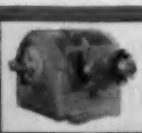
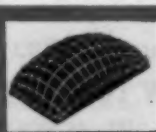


Variable Speed Hydraulic Transmissions



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ational equations is that a common notation must be established before they can be used to the same end as diagrams. Electronic analog computers now on the market have different schemes for wiring or hooking up problems, depending upon the type of patch bay used. This has given rise to a variety of schematic conventions, each of which can use a different operational notation to advantage. However, since all schematic conventions can be reduced to the basic type where the individual capacitors, resistors, etc. are shown or qualified, then the operational notation as explained here or a similar one can be used for all.

From a paper entitled, "Operational Equations for Programming Electronic Analog Computers" presented at Louisiana State University Computing Conference and Southwestern Annual IRE Conference, February, 1955.

HANDLING COSTS IN MATERIALS HANDLING

By B. W. SAUNDERS
Associate Professor
Cornell University

THE ACCOUNTANT is concerned primarily with the functions of recording costs as they occur, liquidating those costs over the various products (which he generally does by arbitrary methods), preparing the customary financial reports for management, the stockholders, the government, and doing such other interpretive work from time to time as management may request. Within this framework, the traditional approach of classifying things as either direct material, direct labor, or overhead has not appreciably changed for many years. Techniques for handling these items have changed, but not the items themselves.

Today with more and more automation, and less and less truly direct labor, we are still clinging to our older concepts of measuring and evaluating things in terms of their direct labor content. A large part of our direct labor is not direct, if we call direct labor that labor which is used to transform by the application of skill a material from one form, state, or position to another form, state, or position. The labor in many cases that is direct by our old standards and definitions is nothing more than the labor of a machine attendant. The skill is in the machine. The operator merely operates the machine. This is less true of assembly operations of course, but it is true of most all processing operations that are done on a production basis.

In the handling operations we have operators also. They, on the other hand, are indirect laborers or operators. This does not seem to be a logical way to differentiate between workers doing jobs, all of which have to be done if we can assume for the moment that layout and processing have been analyzed as to method and the best methods have been employed in each case.

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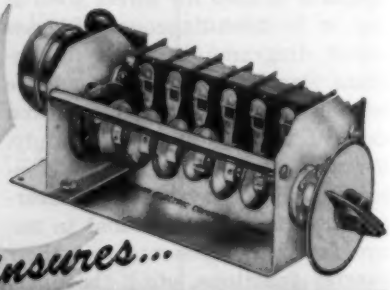

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One must ask the next question then—"Is the saving in cost accounting greater than the expense of uncontrolled handling costs because they haven't been properly identified?" It would appear that cost accountants must rethink their procedures to the extent that machine costs are analyzed properly for all types of machines, labor costs for all types of labor, material costs for all types of material—in short what all direct variable costs are in relation to some product or process and speak of them as just that; namely, the direct costs of production properly related to a realistic base regardless of where they may occur.

This means that all machine costs that are variable should be determined and that standards should be available for the cost of operating that machine per hour of operation.

Perhaps in time direct labor costs will disappear and one would end up with only the material, machine, and overhead costs. This concept is merely a modification of the concept of direct or dynamic costing. It has been known as a method of accounting for upward of 25 years but did not come into use to any appreciable degree until after World War II. The basic concept here, as advocated by its proponents, calls for costing by variable costs only, keeping the costs associated with time or period costs (the fixed costs) out of the cost to make and sell, or in other words out of the inventory values. This then treats the investment costs of equipment as a sunk cost, a cost that has been made and hence is not a factor in subsequent operational decisions involving the use or lack of use of particular pieces of equipment.

It should be pointed out however, that the sunk cost concept is one that occurs only after equipment has been acquired. For the accountant to so consider it and

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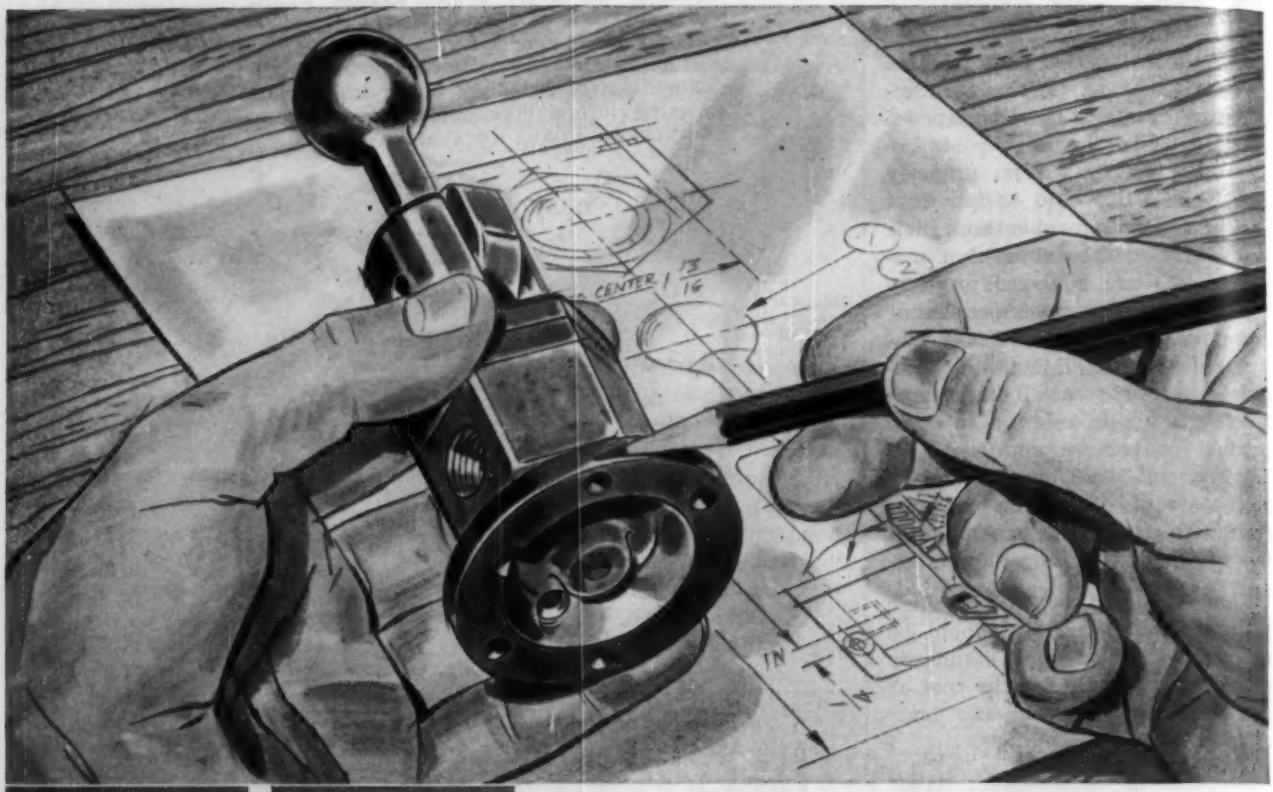

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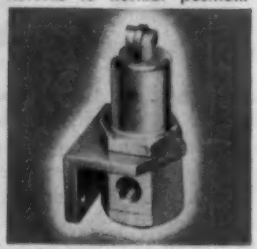

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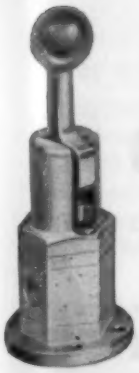

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to operate on a system of variable costs is all right for control purposes after the equipment has been acquired. However, for the engineer who is contemplating the purchase or recommendation of purchase of a particular piece of equipment, certainly the sunk cost concept is not involved prior to actual acquisition. The investment has not been made and hence it is an important factor for him to consider in making any evaluations involving alternative investments. The investment costs after acquisition then become a part of the time or period costs and not variable with production.

It should be pointed out that there exist two separate and distinct evaluations that must be made of materials handling costs. Both however involve the concept of materials handling being a vital part of the overall production system. In the first case one must consider all costs, fixed, variable, as well as alternative operating conditions, in order properly to specify and design a system that appears to offer the lowest overall production cost.

In the second case, one must consider the marginal costs of production in terms of the alternatives that are available with equipment that is already owned and waiting to be used. Materials handling costs are a part of the overall production cost that can neither be ignored as many have in the past, nor treated independently as many do today. Rather they are incremental to the total production cost and should be so considered and so evaluated.

From a paper entitled, "Some Basic Concepts Relating Materials Handling Costs to Overall Production Costs" presented at the Annual Meeting of ASME in Chicago, Nov. 1955.

DATA PROCESSING IN DETROIT

By KERMIT A. PICKETT
Manager
Divisional Records Dept.
Chrysler Corp.

WHILE the Parts Division of Chrysler Corp. has been our largest electronics project with its IBM 702, there are other applications in various stages of completion that vitally affect our future plans in electronics. At our Plymouth Division we have installed and are operating an IBM 650 data processor. This machine puts some teeth into the Plymouth sales program. Fast, daily reporting to sales officials of comparison of car order forecasts against on-order, factory built, and dealer car inventories, along with a variety of trend analyses, pin-point variations for corrective action. The 650 also processes the Plymouth payroll, computes material requirements, and determines vendor releases for our engine assembly line. With only 60 per cent of the machine capacity utilized, we think requirements and releasing for all parts should be next, and then followed by cost of sales.

The Dodge Truck Division is expecting delivery of a Univac File Computer this summer. The file computer will be used to determine material requirements from master vehicle authorizations. Then, it will prepare vendor releases for procurement of material and schedule its delivery. There is ample capacity in the machine to handle payroll, labor distribution, and some of the production reports required by the division.

At our Automotive Body Division, we recently completed a preliminary survey to determine the potential of large scale data processing equipment. The results of the study appeared to be very favorable. Therefore, we have initiated a full scale, detailed study, leading toward the installation of a large scale electronic data processing system. The intent is to develop an integrated system, where many accounting operations will fit very neatly into the manufacturing control operations.

From a talk entitled "Forward Planning" presented at the American Management Association's Second Annual Electronics Conference and Exhibit in New York, Feb. 1956.

LIQUID ROCKET ENGINE DIVISION
AEROJET-GENERAL CORPORATION

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OPPORTUNITY

for

SENIOR ENGINEER

as **HEAD** of

**ANALYSIS SECTION
CONTROLS DEPARTMENT**

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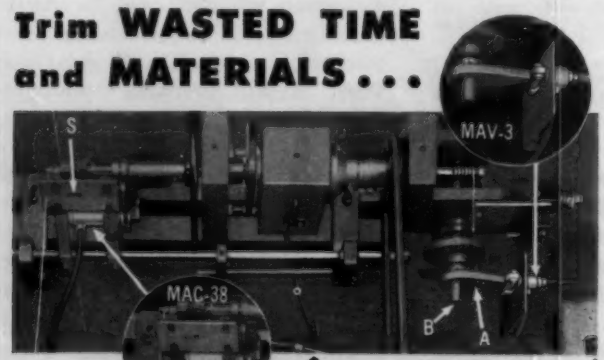

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AUTOMATION patents

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Components

ROTARY MOTION STORAGE DEVICE

A counter mechanism, gear differential, and an electric motor are combined to return a shaft to a selected angular position after displacement from that position. Patent 2,722,379 by Arthur F. Hayek, assigned to General Precision Laboratory Inc.

VOLTAGE AMPLITUDE QUANTIZER AND CODER

A number of impulses proportional to the voltage amplitude of an electric signal are produced by means of a cathode ray tube with a slotted opaque mask on its face and a photocell receiving light impulses through the slots. Patent 2,733,358 by Lawrence T. Carapellotti, assigned to United States of America.

• • •

Controls

ELECTRICAL CONTROL MECHANISM

This mechanism for controlling several pieces of electrical apparatus includes contacts to be passed across a pattern card perforated to give a contacting pattern. The means to advance the contact carriage includes provision to automatically return to starting position on completion of a cycle. Patent 2,731,572 by Arthur J. Cobert.

• • •

Data Processing

MAGNETIC BINARY DEVICE

Registration of binary values is possible with a device comprising several magnetic elements having two remnant states of substantial saturation. Each element has windings through which voltage pulses can be passed to change its remnant state. The separate elements and windings are so designed that different energizing currents are necessary to change the various elements. Patent 2,735,021 by Ole K. Nilssen, assigned to Radio Corp. of America.

Handling

STACK ELEVATOR AND CONTROL THEREFOR

Support for a stack of sheets is automatically elevated to a predetermined level in accordance with periodic determinations of the level of the top of the stack by a suction device. Patent 2,733,920 by George W. von Hofe and Edwin K. Wolff, assigned to New Jersey Machine Corp.

ARTICLE FEEDING MECHANISM

To space articles moving unidirectionally along a straight path, an element having a helical groove in its periphery forms one side of said path. This element is rotated and is urged toward a flat plate forming the opposite side of the path. Patent 2,730,226 by Carl L. Day and Rudolph H. Breeback, assigned to Crown Cork & Seal Co. Inc.

• • •

Machines

APPARATUS FOR SLITTING CARTONS

Sealed cartons moving on a conveyor are cut in two by two pairs of slitters. The slitter supports include means to hold the slitters in cutting engagement with the carton as it moves between them. Patent 2,729,885 by Albert J. Wahl and Charles A. Lanz, assigned to A. J. Wahl Inc.

• • •

Measuring

STRIP WIDTH GAGE

Distance between opposite edges of a moving strip is determined by photoelectric units mounted on carriages for movement transversely of the strip. Patent 2,730,006 by Paul P. Gottschall, assigned to United States Steel Corp.

AUTOMATIC WEIGHING SCALE

A beam of light is reflected from a balance arm to two photoelectric devices which produce opposed dc voltages. When the scale is in balance, the voltages are equal. The unknown force is balanced by a magnetic force created by a measured current flow. Patent 2,734,735 by Robert E. Payne, assigned to the Sharples Corp.

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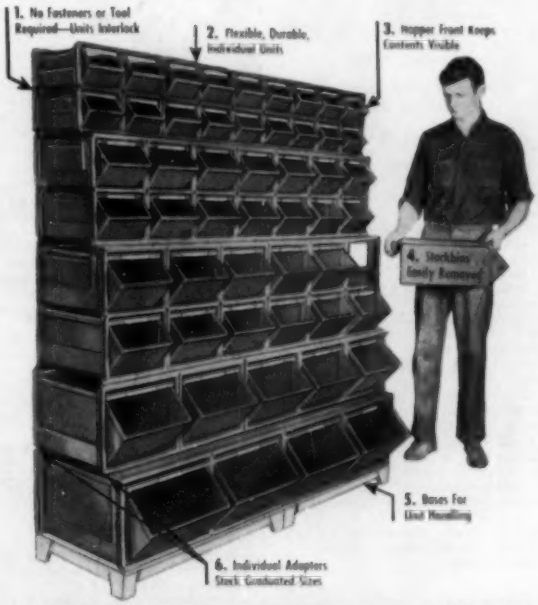
Advertising man wanted for technical products. Previous advertising experience not necessary but helpful. Must have at least two or three years of college with courses in engineering and technical subjects and like to write. If you have the qualifications we have an opportunity open for you. Man selected will be trained in all phases of industrial advertising. In your letter of application state age, education, positions held, and give statement of why you want a career in advertising. Location: well-known Connecticut company. **Address Box 107, AUTOMATION, Penton Building, Cleveland 13, Ohio.**

AUTOMATION STARTS WITH CONTROLLED HANDLING OF PARTS, TOOLS and MATERIALS


1. No Fasteners or Tool Required—Units Interlock
2. Flexible, Durable, Individual Units
3. Hopper Front Keeps Contents Visible
4. Stackbins Easily Removed
5. Bases For Unit Handling
6. Individual Adapters Stock Graduated Sizes

LOW-COST, STACKBIN-IN-STACKRACK UNITS PAY FOR THEMSELVES IN 3 WAYS

SAVE SPACE — Individual units stack easily and lock securely as high and as long as you need. Seven different size units available.

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Government Publications

Printed Circuits. *Report* PB100950 *by National Bureau of Standards, 99 pages, available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.;* $1.75.

Final report for the Bureau of Aeronautics, U. S. Navy, January 1950, summarizes techniques, materials and component parts that find application in the design of printed circuits. Use of many new concepts and techniques is described. A printing press was developed, and possibilities of adapting it to automatic printing of circuits on cylindrical shapes are explored.

On the Mechanics of Magnetic Amplifier Operation. *Report* PB 104106 *by Naval Research Laboratory, 28 pages, available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.;* 75c.

This interim report dated January 1951 presents a new theory of magnetic amplifier operation. An elementary quasi-mathematical approach is used to illustrate application of this theory to known circuits and to predict new ones. These circuits are said to have characteristics superior to those of other magnetic amplifier circuits.